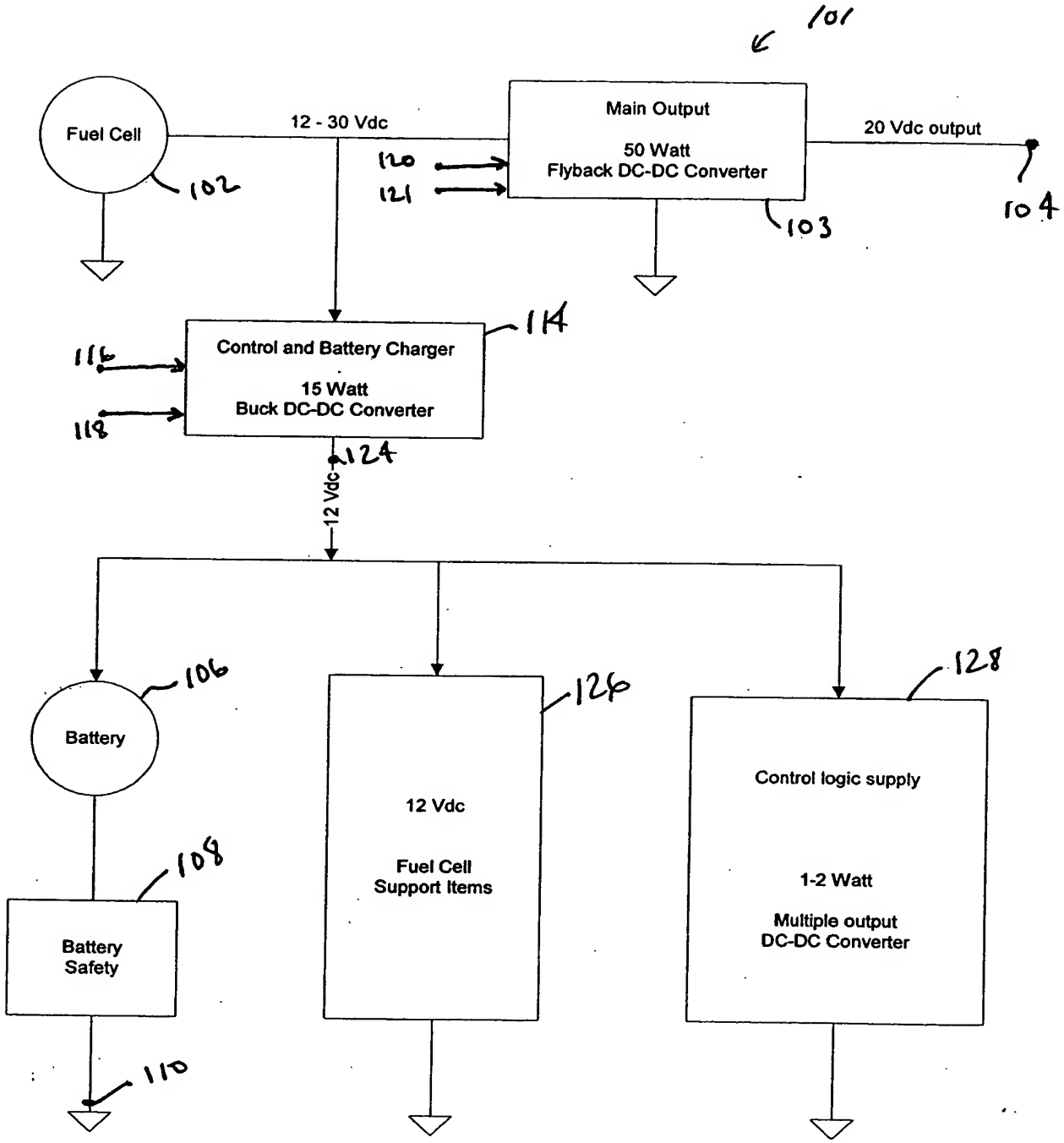

101
Fuel Cell
102
12 - 30 Vdc
Main Output
50 Watt
Flyback DC-DC Converter
103
20 Vdc output
104
120
121
Control and Battery Charger
15 Watt
Buck DC-DC Converter
114
116
118
124
12 Vdc
Battery
106
Battery
Safety
108
110
12 Vdc
Fuel Cell
Support Items
126
Control logic supply
1-2 Watt
Multiple output
DC-DC Converter
128

FIG. 1

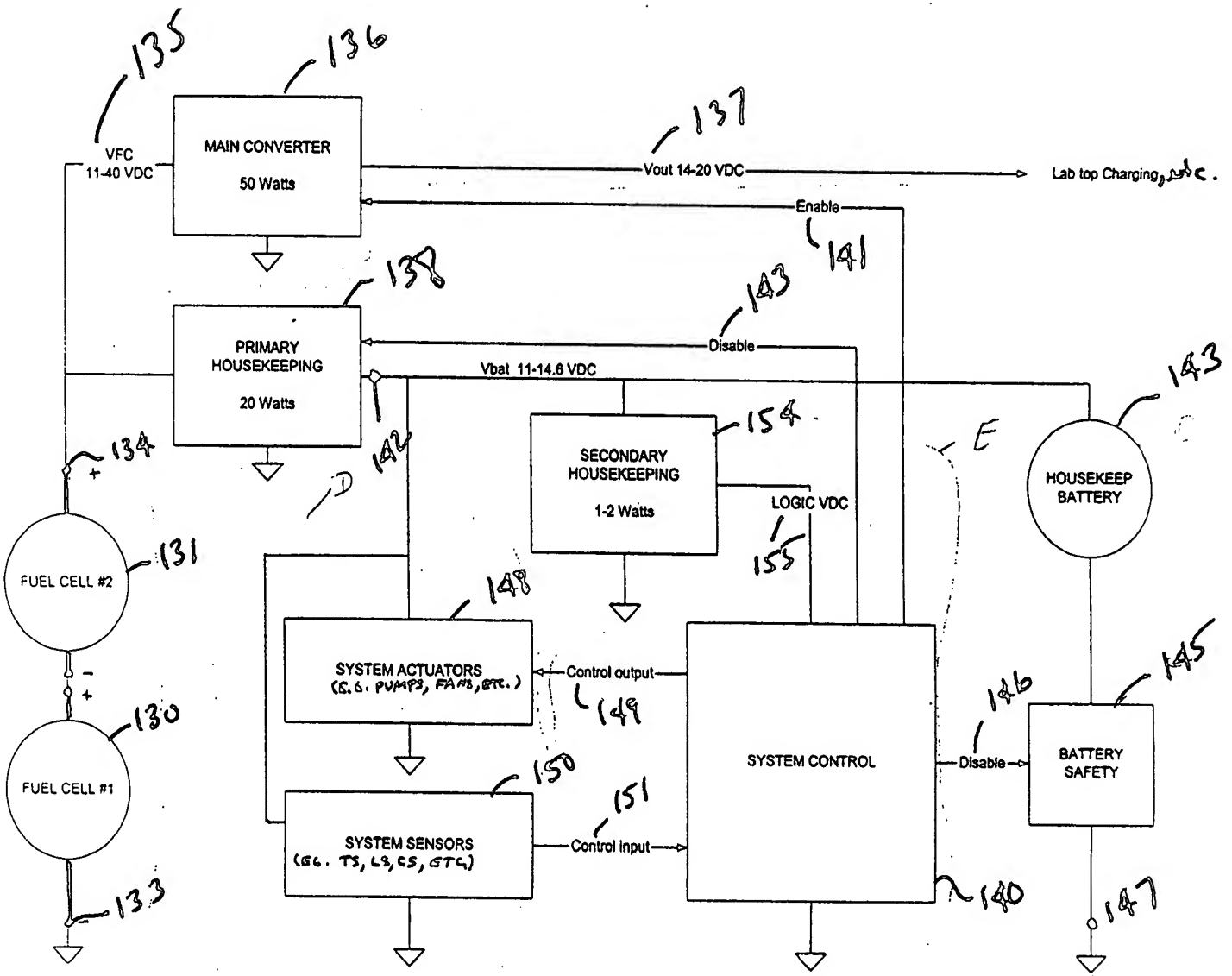

135
136
137
MAIN CONVERTER
50 Watts
VFC
11-40 VDC
Vout 14-20 VDC
Lab top Charging, etc.
Enable
141
138
143
PRIMARY
HOUSEKEEPING
20 Watts
Disable
Vbat 11-14.6 VDC
143
154
SECONDARY
HOUSEKEEPING
1-2 Watts
LOGIC VDC
155
HOUSEKEEP
BATTERY
134
142
D
E
FUEL CELL #2
131
148
SYSTEM ACTUATORS
(E.G. PUMPS, FANS, ETC.)
Control output
149
SYSTEM CONTROL
146
145
Disable
BATTERY
SAFETY
130
FUEL CELL #1
150
151
SYSTEM SENSORS
(EG. TS, LS, CS, ETC)
Control Input
140
133
147

FIG. 2

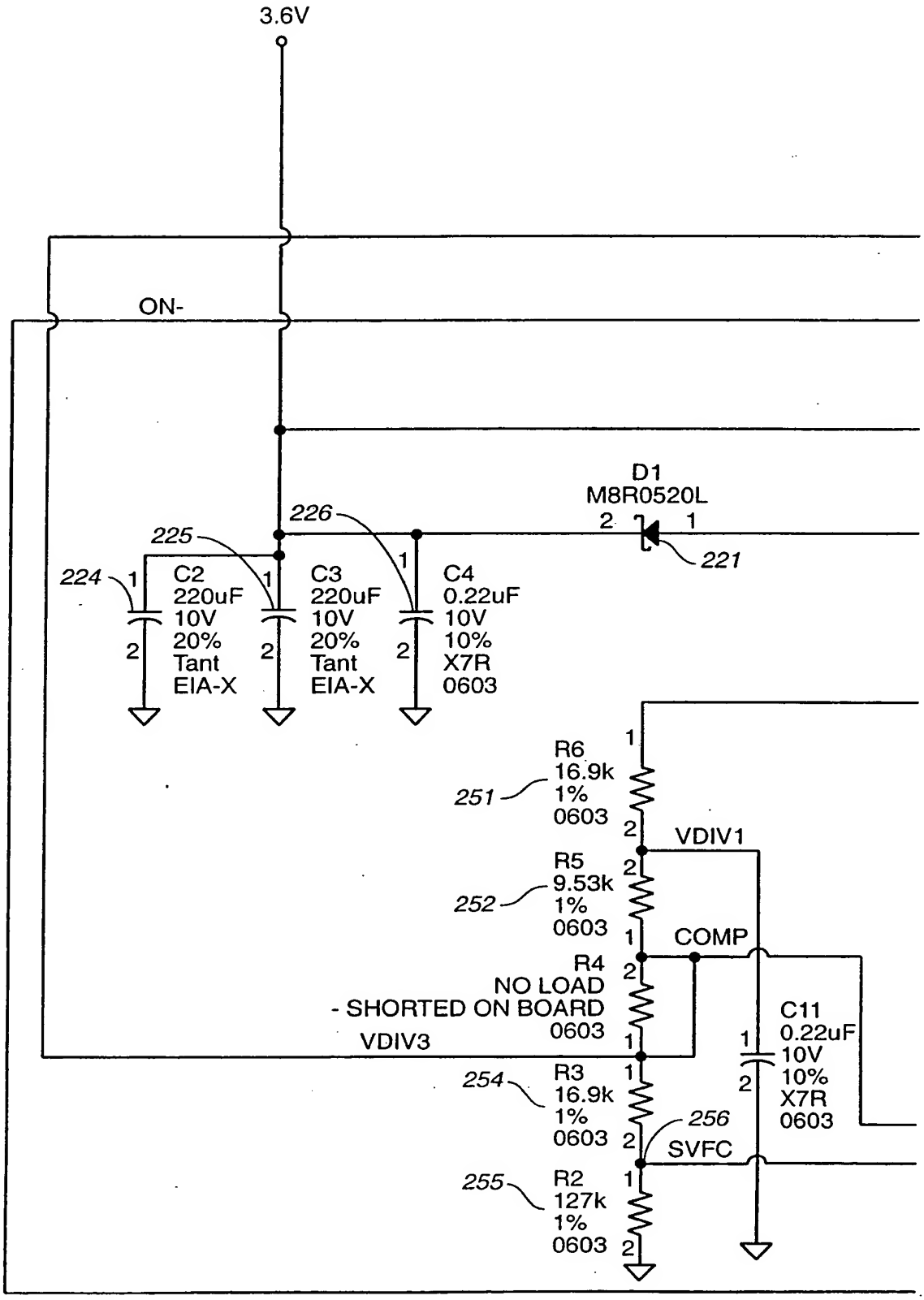

3.6V
ON-
D1
M8R0520L
2
1
221
226
225
224
C2
220uF
10V
20%
Tant
EIA-X
C3
220uF
10V
20%
Tant
EIA-X
C4
0.22uF
10V
10%
X7R
0603
R6
16.9k
1%
0603
251
VDIV1
R5
9.53k
1%
0603
252
COMP
R4
NO LOAD
- SHORTED ON BOARD
0603
VDIV3
C11
0.22uF
10V
10%
X7R
0603
R3
16.9k
1%
0603
254
256
SVFC
R2
127k
1%
0603
255

FIG. 3a-1

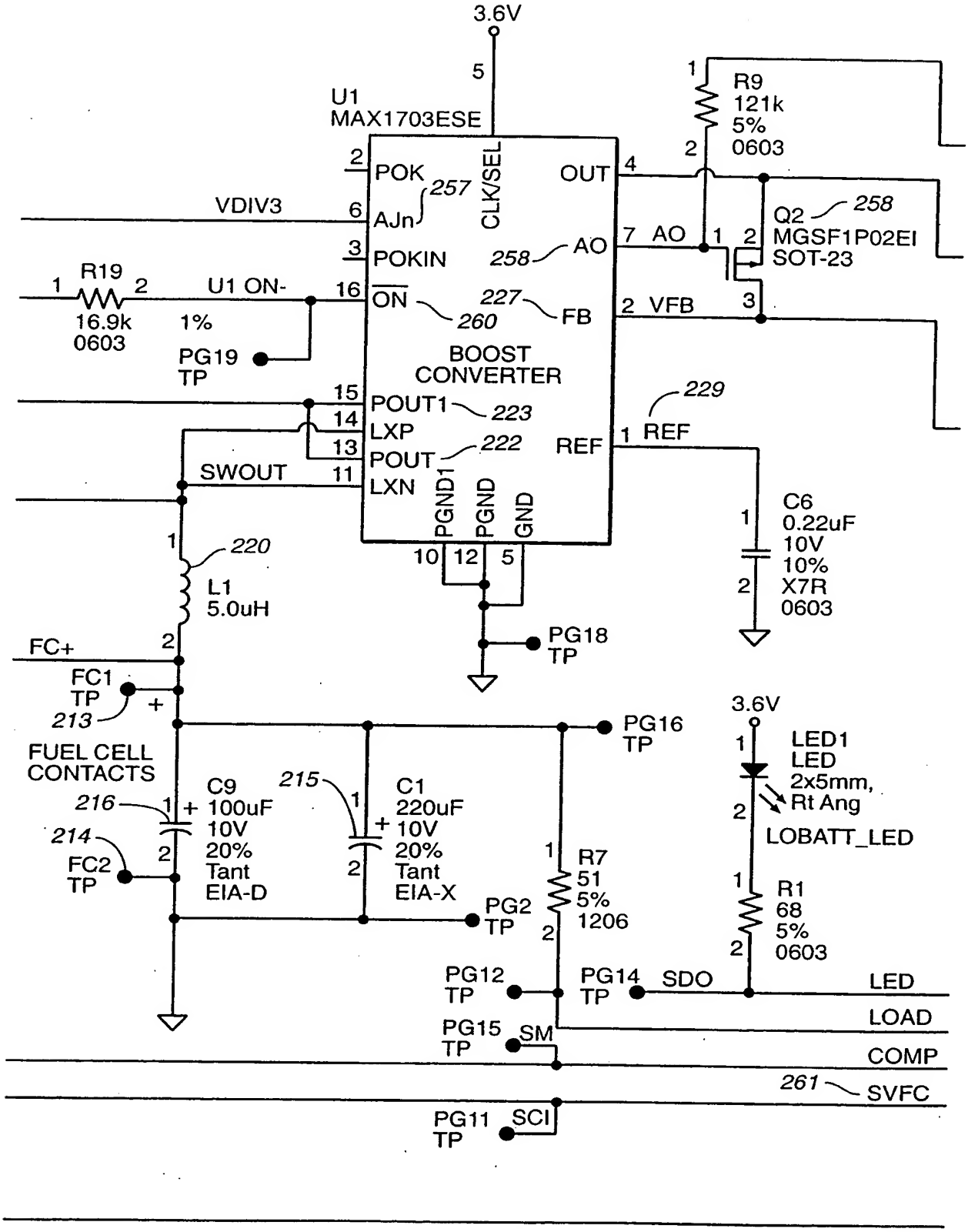

3.6V
U1
MAX1703ESE
POK
257
AJn
CLK/SEL
OUT
VDIV3
POKIN
258
AO
R19
16.9k
0603
1%
U1 ON-
ON
227
260
FB
PG19
TP
BOOST
CONVERTER
POUT1
223
LXP
POUT
222
REF
229
SWOUT
LXN
PGND1
PGND
GND
220
L1
5.0uH
PG18
TP
R9
121k
5%
0603
Q2
258
MGSF1P02EI
SOT-23
AO
VFB
C6
0.22uF
10V
10%
X7R
0603
FC+
FC1
TP
213
FUEL CELL
CONTACTS
C9
100uF
10V
20%
Tant
EIA-D
216
214
FC2
TP
215
C1
220uF
10V
20%
Tant
EIA-X
PG2
TP
PG16
TP
R7
51
5%
1206
3.6V
LED1
LED
2x5mm,
Rt Ang
LOBATT_LED
R1
68
5%
0603
PG12
TP
PG14
TP
SDO
LED
LOAD
PG15
TP
SM
COMP
261
SVFC
PG11
TP
SCI

FIG. 3a-2

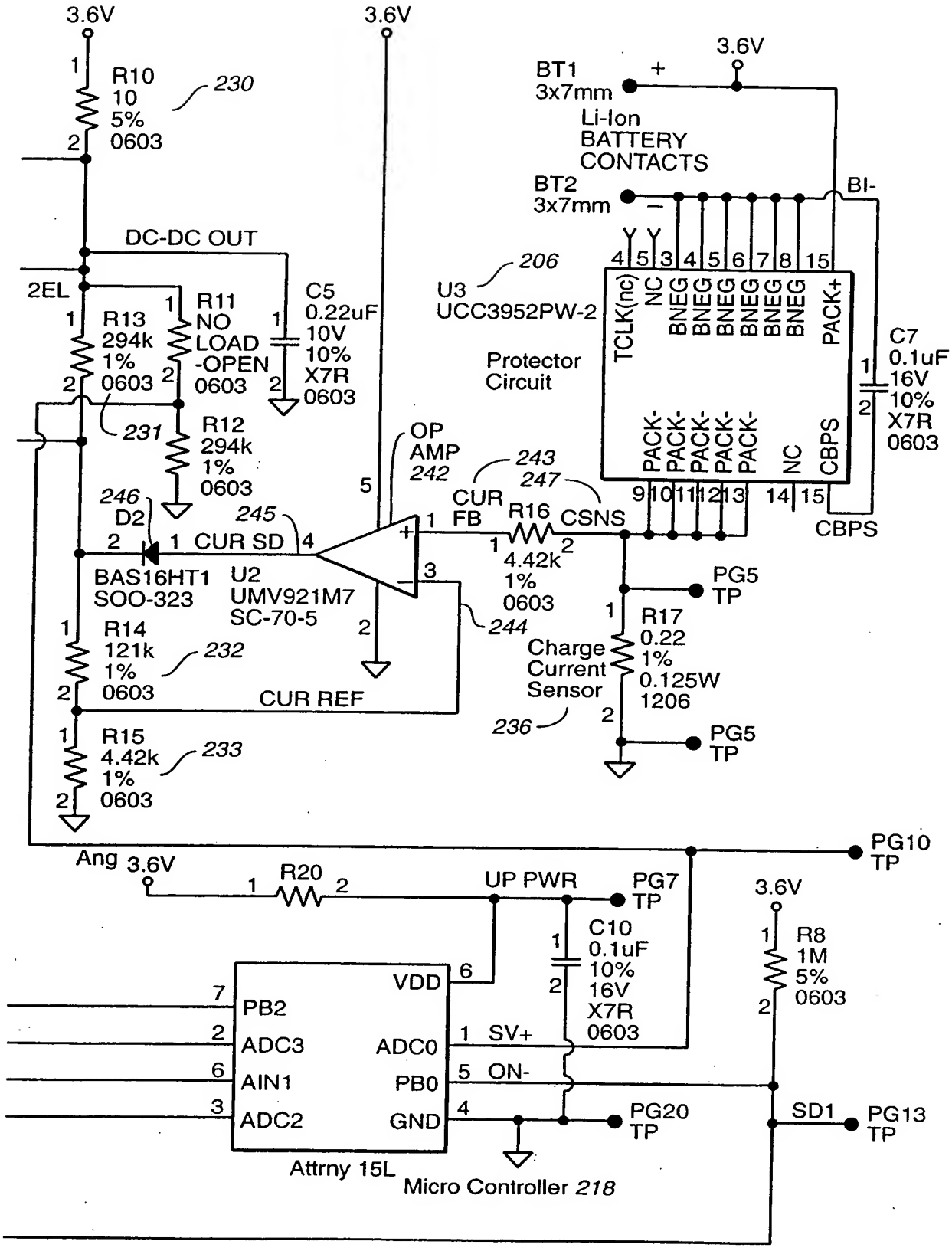

3.6V
R10
10
5%
0603
230
DC-DC OUT
2EL
R13
294k
1%
0603
231
R11
NO
LOAD
-OPEN
0603
C5
0.22uF
10V
10%
X7R
0603
R12
294k
1%
0603
246
D2
BAS16HT1
SOO-323
245
CUR SD
U2
UMV921M7
SC-70-5
OP
AMP
242
243
CUR
FB
247
R16
CSNS
4.42k
1%
0603
244
R14
121k
1%
0603
232
CUR REF
R15
4.42k
1%
0603
233
BT1
3x7mm
Li-Ion
BATTERY
CONTACTS
BT2
3x7mm
BI-
206
U3
UCC3952PW-2
TCLK(nc)
NC
BNEG
PACK+
PACK-
NC
CBPS
Protector
Circuit
C7
0.1uF
16V
10%
X7R
0603
CBPS
PG5
TP
R17
0.22
1%
0.125W
1206
Charge
Current
Sensor
236
PG10
TP
Ang
R20
UP PWR
PG7
C10
0.1uF
10%
16V
X7R
0603
R8
1M
5%
0603
PB2
ADC3
AIN1
ADC2
VDD
ADC0
PB0
GND
SV+
ON-
PG20
SD1
PG13
Attrny 15L
Micro Controller 218

FIG. 3a-3

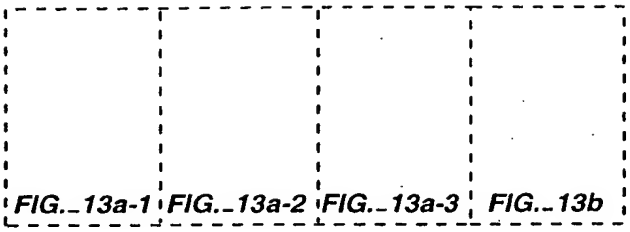


FIG._13a-1
FIG._13a-2
FIG._13a-3
FIG._13b

FIG. 3a

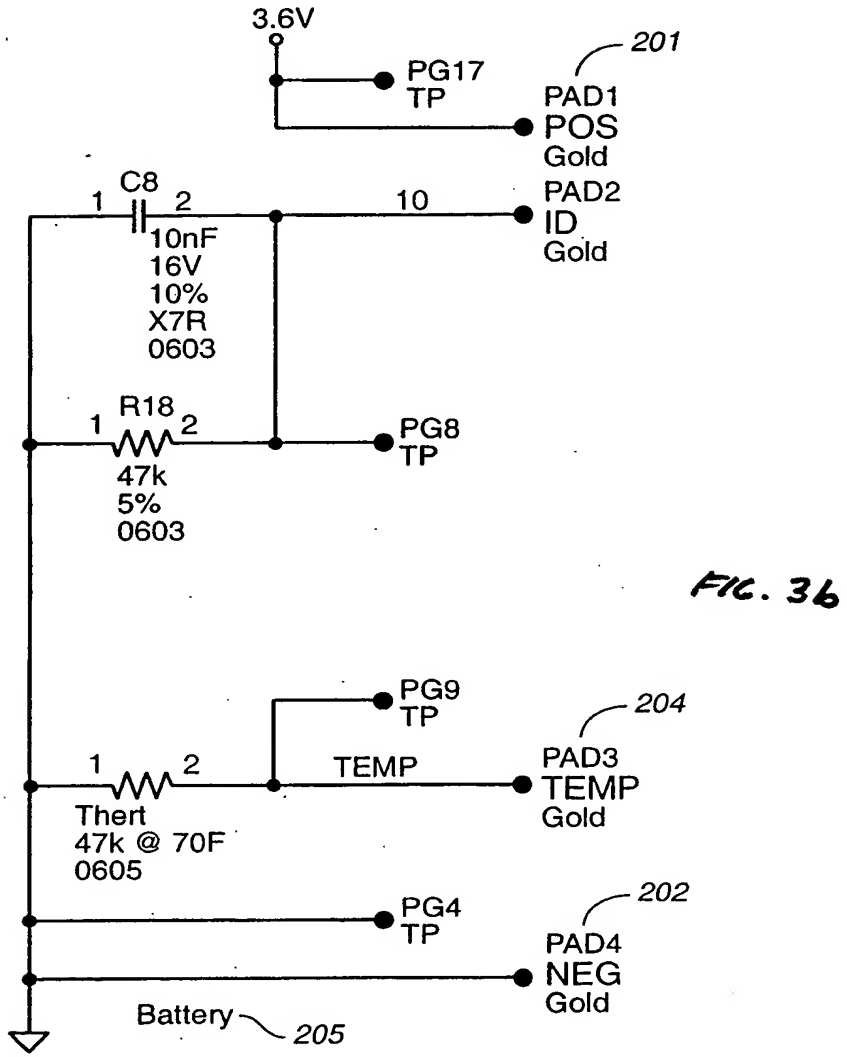

3.6V
PG17
TP
201
PAD1
POS
Gold
C8
1
2
10nF
16V
10%
X7R
0603
10
PAD2
ID
Gold
R18
1
2
47k
5%
0603
PG8
TP
PG9
TP
204
1
2
TEMP
PAD3
TEMP
Gold
Thert
47k @ 70F
0605
PG4
TP
202
PAD4
NEG
Gold
Battery
205

FIG. 3b

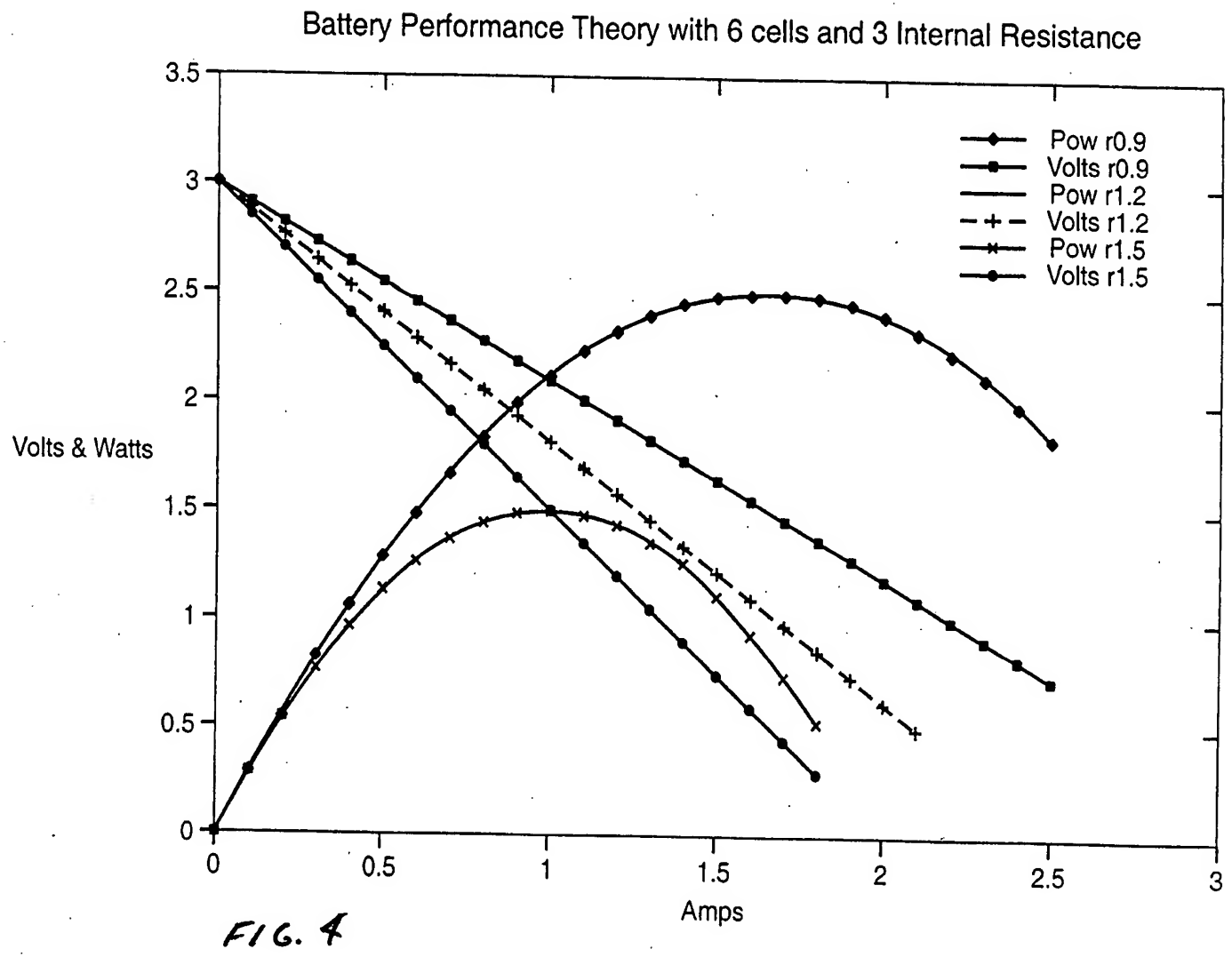

Battery Performance Theory with 6 cells and 3 Internal Resistance
Volts & Watts
Amps
Pow r0.9
Volts r0.9
Pow r1.2
Volts r1.2
Pow r1.5
Volts r1.5
0
0.5
1
1.5
2
2.5
3
3.5

FIG. 4

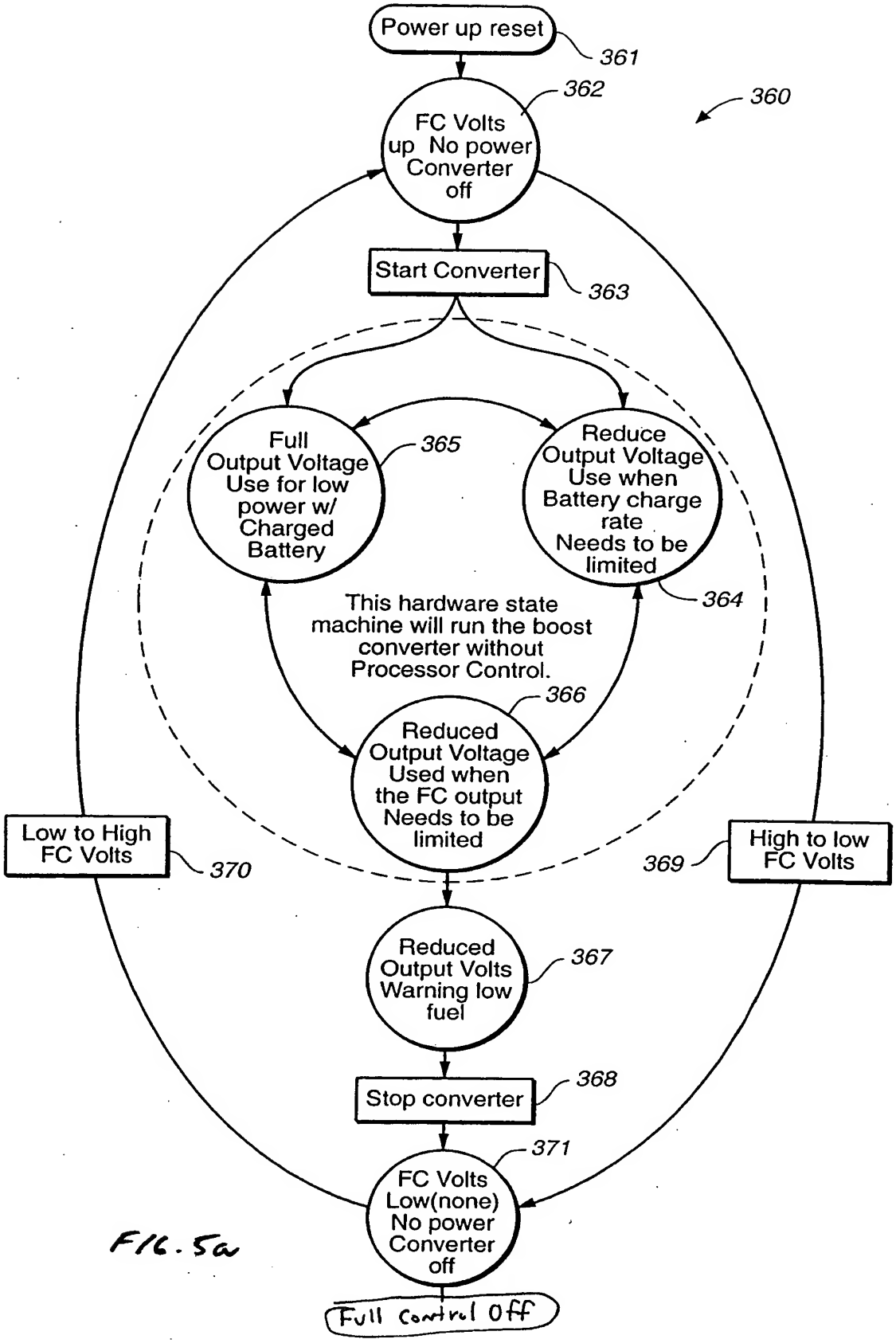

Power up reset
361
362
360
FC Volts up No power Converter off
Start Converter
363
Full Output Voltage Use for low power w/ Charged Battery
365
Reduce Output Voltage Use when Battery charge rate Needs to be limited
364
This hardware state machine will run the boost converter without Processor Control.
366
Reduced Output Voltage Used when the FC output Needs to be limited
Low to High FC Volts
370
369
High to low FC Volts
Reduced Output Volts Warning low fuel
367
Stop converter
368
371
FC Volts Low(none) No power Converter off
Full Control Off

FIG. 5a

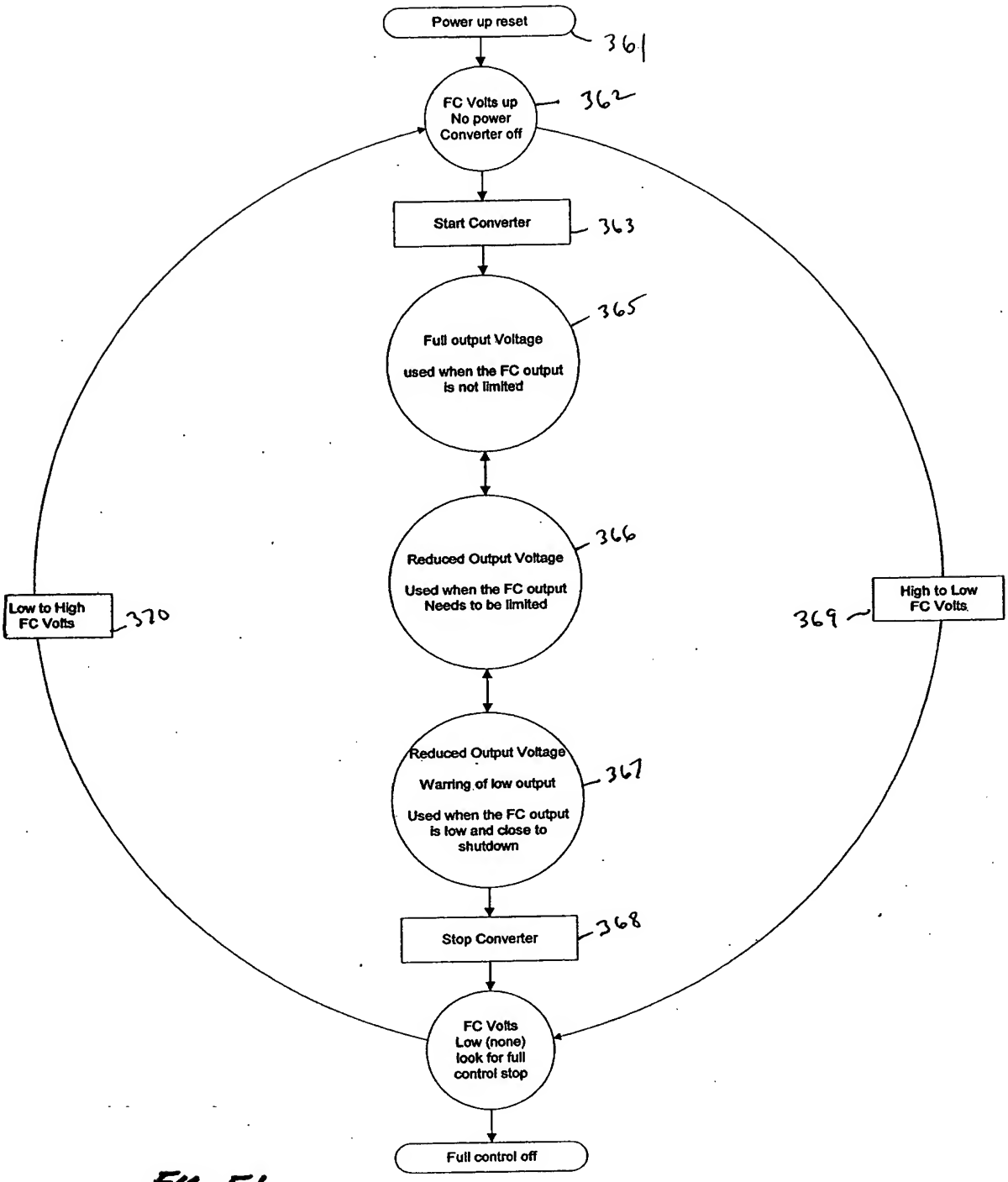

Power up reset
361
FC Volts up
No power
Converter off
362
Start Converter
363
Full output Voltage
used when the FC output
is not limited
365
Reduced Output Voltage
Used when the FC output
Needs to be limited
366
Reduced Output Voltage
Warning of low output
Used when the FC output
is low and close to
shutdown
367
Stop Converter
368
FC Volts
Low (none)
look for full
control stop
Full control off
Low to High
FC Volts
370
High to Low
FC Volts
369

FIG. 5b

Software VFC Levels

Level 1 - 2.4V If OFF Load Test Above, with Warning
Level 2 - 1.5V If ON Sleep Above
Level 3 - 1.2V If ON Warning Below
Level 4 - 1.1V If ON Stop Below

Hardware Trip from Sleep is Between L2-L3

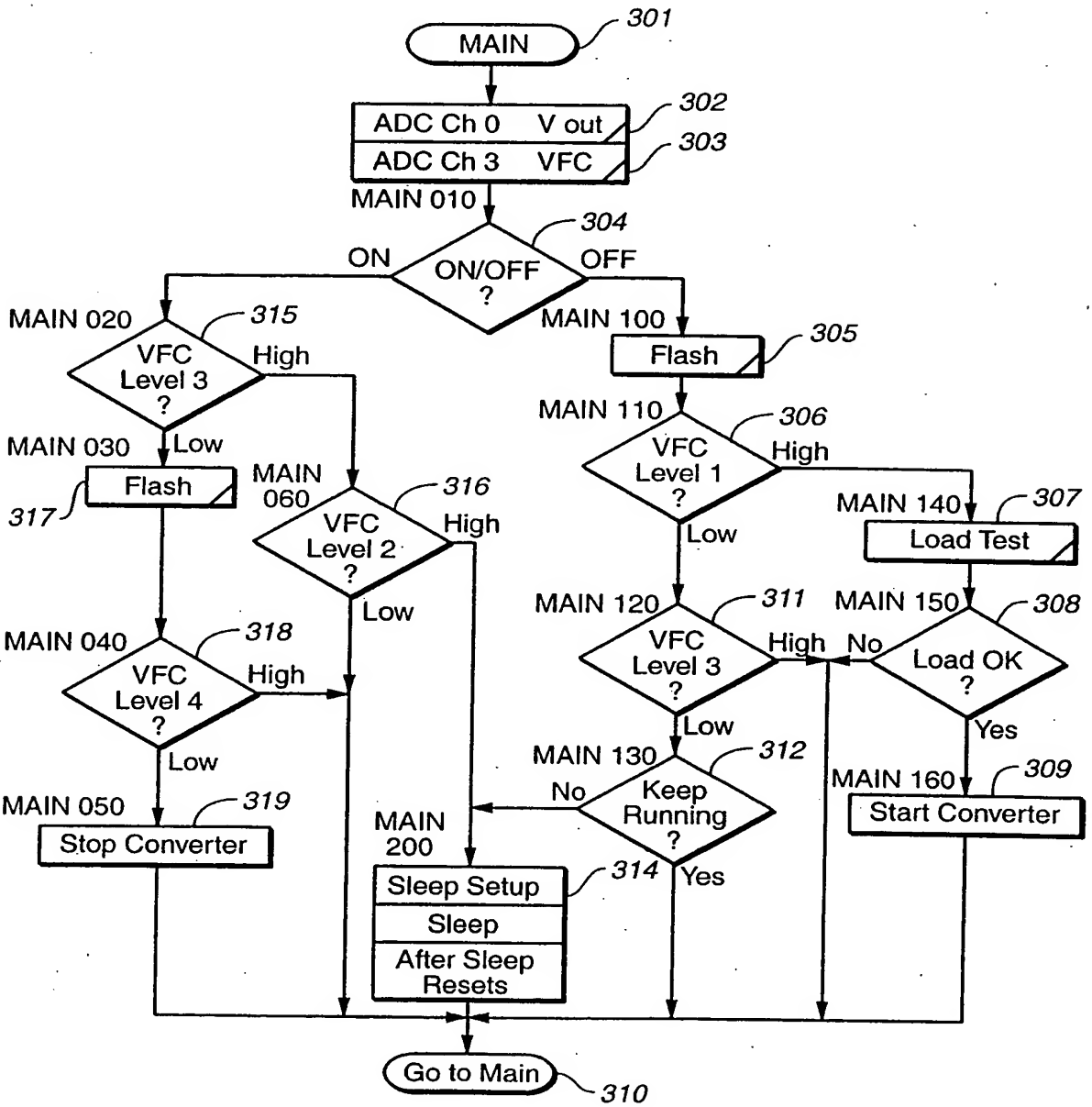


FIG. 6

Software VFC Levels

Level 1 - 2.4V If OFF Load Test Above, with Warning
Level 2 - 1.5V If ON Sleep Above
Level 3 - 1.2V If ON Warning Below
Level 4 - 1.1V If ON Stop Below

Hardware Trip from Sleep is Between L2-L3

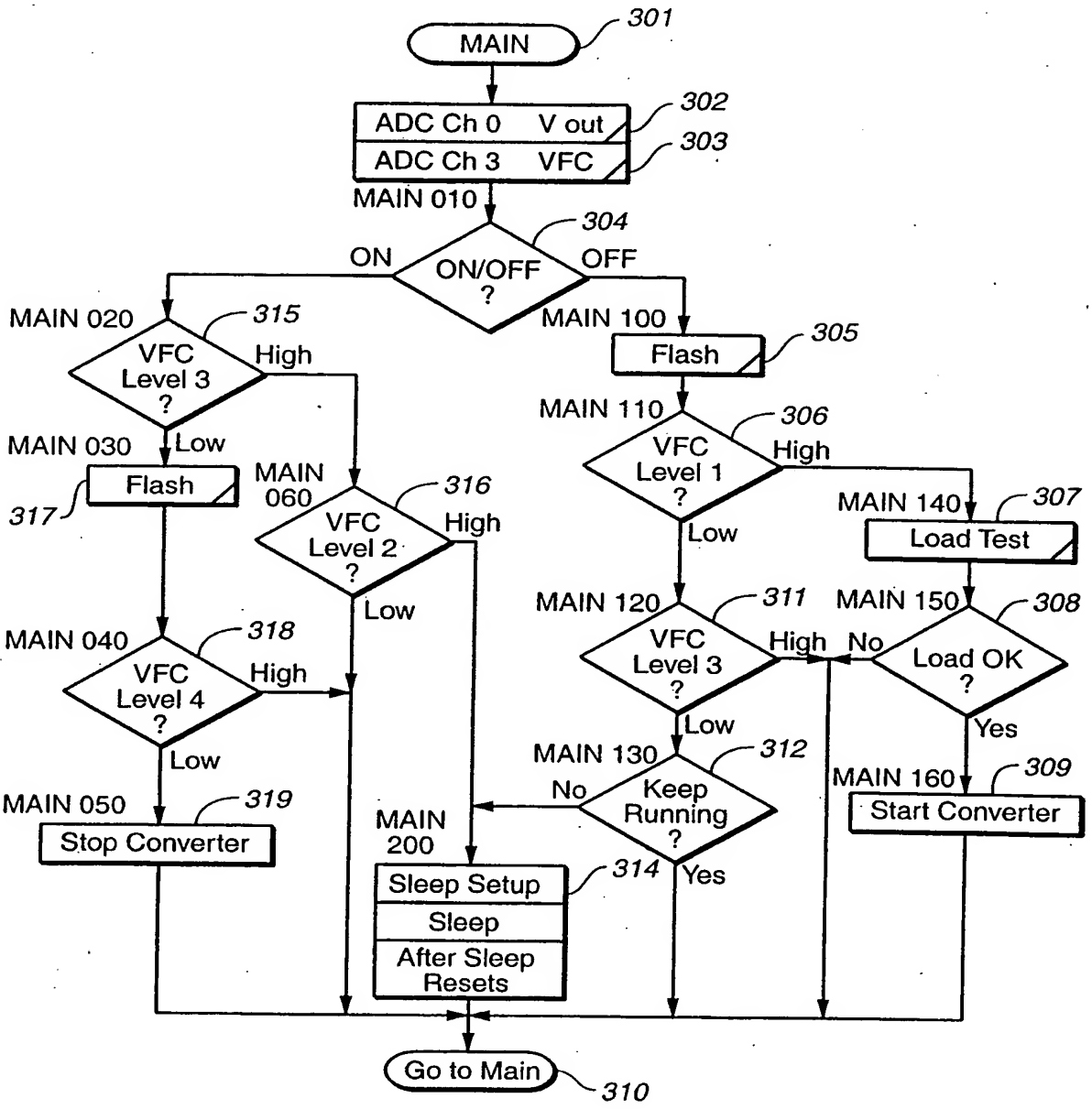


FIG. 7a

```
; Code file for                Stepup boost convertr
;
;
;
;

.include "tnlSde5.inc: ; supplies all std port and pin refances for tiny15
.include "constdef.inc" ; supplies init values

; regesters Defenations

.DEF    LOADOK      = r14    ; flag for load ok = 1
.DEF    TEMPF       = r15    ; Temp for flages
.DEF    VCCLOW      = r16    ; Voltage VCC
.DEF    VCCHIGH     = r17    ;
.DEF    VFCLALOW    = r18    ; Voltage FC under load
.DEF    VFCLAHIGH   = r19    ;
.DEF    VFCBALOW    = r20    ; Voltage FC main
.DEF    VFCBAHIGH   = r21    ;
.DEF    VFCDIFLOW   = r23    ; Load difrance
.DEF    VFCDIFHIGH  = r24    ;
.DEF    FLASHLOW    = r25    ; Flash Count for total stop
.DEF    FLASHHIGH   = r26    ;
.DEF    TICB        = r27    ; tic count A
.DEF    TICA        = r28    ; tic count B
.DEF    TEMP        = r29    ; For I/O transfer

; Port B Pins definatiions
.EQU    ONNOT       = 0      ; Digital out port
.EQU    LED         = 2      ; Digital out port
.EQU    LOAD        = 4      ; Digital out port
.EQU    SVCC        = 0      ; ADC Channel
.EQU    SVFC        = 2      ; ADC Channel
.EQU    Comp        = 1      ; Port (Compartor)

.EQU    VCCLOWN     = 16     ; Reg pointer assignments
.EQU    VFCLAN      = 18     ; Reg pointer assignments
.EQU    VFCBAN      = 20     ; Reg pointer assignments

.EQU    FLASHDEL    = 50     ; 5 sec flash start delay
.EQU    TICFLASH    = 10     ; ticks per cycle
.EQU    LOADDEL     = 150    ; 15 sec to first load test
.EQU    TICLOAD     = 100    ; ticks per load test

.EQU    STOPED      = 1      ; flasher stioed

.CSEG

; TSR Vectors
                     rjmp     RESET          ; Reset Handler
                     reti                    ; External Intrupt, Not used
                     reti                    ; Pin Change Handler, Not used
                     rjmp     TIM1_CMP       ; Timer 1 compare match, used for 0.1
sec tic

                     reti;TIM1 OVF           ; Timer 1 overflow handler, Not used
                     reti;TIM0_OVF           ; Timer 0 overflow handler, used for
short sub tic time

                     reti;EE_RDY             ; EEPROM Ready handler
                     reti;ANA_COMP           ; Analog Comparator Handler for Level
1.5 Fuel cell volts
```

FIG. 7b

```
                reti            ; ADC           ;  ADC Conversion handler
MAIN:           ;  Main Program start

                ;  read adc Ch for SVcc base
                ldi             ZH,SVCC         ;  set chanel
                ldi             ZL,VCCLOWN      ;  data store pointer
                rcall           ADCRUN          ;  call ACD Converter

                ;  read adc ch for SVFC
                ldi             ZH,SVFC         ;  set chanel
                ldi             ZL,VFCBAN       ;  data store pointer
                rcall           ADCRUN          ;  call ACD Converter
                ;ldi            VFCBAHIGH,$03       ; • • • test for VFC
                ;ldi            VFCBALOW,$5e
                ;ldi            VFCLAHIGH,$02   ; • • • test for VFC
                ;ldi            VFCLALOW,$ff
                ;cbi            ddrB,onnot
MAIN010:        ;  test OFF/ON
                sbic            PINB,ONNOT      ;  read ON pin
                rjmp            MAIN100

MAIN020:        ;  test vfc for level 3
                cpi             VFCBALOW,low(LEVEL3)
                ldi             TEMP,high(LEVEL3)
                cpc             VFCBAHIGH,TEMP
                brsh            MAIN060         ;  the value is equ or high
MAIN030:        rcall           FLASH           ;  do flash
MAIN040:        ;  test vfc for level 4
                cpi             VFCBALOW,low(LEVEL4)
                ldi             TEMP,high(LEVEL4)
                cpc             VFCBAHIGH,TEMP
                brsh            MAIN            ;  the value is equ or high, loop to
main            ;  rjmp         MAIN050         ;  the value is low fall or jump
MAIN050:        ;  Stop the converter
                sbi             PORTB,ONNOT     ;  Stop Converter and test led
                rjmp            MAIN            ;  loop to main
MAIN060:        ;  test vfc for level 2
                cpi             VFCBALOW,low(LEVEL2)
                ldi             TEMP,high(LEVEL2)
                cpc             VFCBAHIGH,TEMP
                brsh            MAIN200         ;  the value is equ or high
                rjmp            MAIN            ;  the value is low fall or jump

                ;  do flashe
MAIN100:        rcall           FLASH           ;  do flash
MAIN110:        ;  test vfc for level 1
                cpi             VFCBALOW,low(LEVEL1)
                ldi             TEMP,high(LEVEL1)
                cpc             VFCBAHIGH,TEMP
                brsh            MAIN140         ;  the value is equ or high
                ;  rjmp         MAIN120         ;  the value is low fall or jump
MAIN120:        ;  test vfc for level 3
                cpi             VFCBALOW,low(LEVEL3)
                ldi             TEMP,high(LEVEL3)
                cpc             VFCBAHIGH,TEMP
```

FIG. 7c

```
                brsh        MAIN                ; the value is equ or high
                ; rjmp      MAIN130             ; the value is low fall or jump

MAIN130:        ; test Flasher for stoped
                cpi         FLASHHIGH, STOPED
                breq        MAIN200             ; we need to sleep
                rjmp        MAIN                ; keep looping

MAIN140:        ; do load test
                rcall       LOADTEST            ; test the load

MAIN150:        ; Test for load OK
                tst         LOADOK
                breq        MAIN                ; go to main

MAIN160:        ; start the converter
                cbi         PORTB, ONNOT        ; Start Converter
                clr         FLASHLOW            ; Stop Flashing
                clr         FLASHHIGH
                rjmp        MAIN                ; keep looping

MAIN200:        ; enter sleep mode
                cbi         ADCSR, ADEN         ; Power down the ADC
                clr         TICA
                clr         TICB
                ldi         TEMP, 0             ; stop timer int
                out         TIMSK, TEMP

                ldi         TEMP, MCUCRSET      ; set for idel
                out         MCUCR, TEMP
                ; may have to stop timers adc intrrupts
                ;sbi        ddrb, led           ;*******
                sleep       ;  wate COMPARE
                ;cbi        ddrb, led           ; *****

MAIN210:        ; nop
                ; nop
                ; rjmp      MAIN210             ; we will wate hear for a low level 2
transet
                ldi         TEMP, TIMSKSET      ; Enable timer int
                out         TIMSK, TEMP

                sbi         ADCSR, ADEN         ; Power up the ADC
                rjmp        MAIN                ; back to looping


; Place init code hear
RESET:          ; Clear Requesters
                clr         r0                  ; Clear a master
                ldi         z1,29               ; Point to req r29
                st          z,r0                ; Clear
RESET01:        dec  z1     ;  set for next
                brne        RESET01             ; loop

                ; Setup the ADC
                ldi         TEMP, ADCSRSET
                out         ADCSR, TEMP
                sbi         ADCSR, ADEN  ; Power up the ADC

                ; Setup the comparitor
                ldi         TEMP, ACSRSET
                out         ACSR, TEMP

                ; Setup timer 0 for div 64
                ldi         TEMP, TCCR0SET
```

FIG. 7d

```
                out         TCCR0, TEMP

                ; Setup Timer 1 for 1.ms int
                ldi         TRMP, TCCR1SET
                out         TCCR1, TEMP
                ldi         TEMP, OCR1ASET
                out         OCR1A, TEMP

                ; Setup Port B
                ldi         TEMP, DDRBSET       ; Data direction
                out         DDRB, TEMP
                ldi         TEMP, PORTBSET
                out         PORTB, TEMP

                ; ldi        ticb, 100

                ; Enable Interrupts
                ldi         TEMP, TIMSKSET      ; Enable timer int
                out         TIMSK, TEMP
                ldi         TEMP, GIMSKSET      ; Set the mask
                out         GIMSK, TEMP
                ldi         TEMP, SREGSET       ; Enable
                out         SREG, TEMP

                ; Setup sleep
                ldi         TEMP, MCUCRSET
                out         MCUCR, TEMP

                ; setup start delays
                ldi         TICA, FLASHDEL      ; flash start delay
                ldi         TICB, LOADDEL       ; load start delay

RESETEND:       rjmp        MAIN


; This ISR will dec the Time regesters tica and ticb to 0
TIM1_CMP:
                in          TEMPF, SREG         ; save status
                tst         tica
                breq        tic01
                dec         tica
Tic01:          tst         ticb
                breq        tic02
                dec         ticb
Tic02:          out         SREG, TEMPF         ; Restor status
                reti

; This ISR will handal end of time 0 overflows
TIM0_OVF:       ; we ret at vector
                reti

; This ISR will handal changes in FC Volts it will retern to last place
ANA_COMP:
                ; we may whant to fix timer for fast service in main

                reti

ADC:            reti

EE_RDY:         reti                            ; This ISR may be used
later

TIM1_OVF:       reti                            ; This ISR will be
disabled
```

FIG. 7e

```
;  Rutine to manage low fuel flasher
;  The two byte flash count also acts as a run flag as follows:
;          Low byte not 0, the counter is active and flashing
;          Low byte equ 0, the high byte has meaning as follws:
;                  0 =  clear to start flashing
;                  1 =  flash time complet
;
;                  any other go to sleep

FLASH:          ; Start Flasher

                tst             TICA                    ; test for time to run
                brne            FLASHEND                ; must be zero th run
                ldi             TICA, TICFLASH          ; reset the timer

                tst             FLASHLOW                ; test for need
                brne            FLASH10                 ; go to flashing
                tst             FLASHHIGH               ; test for stoped
                brne            FLASHEND                ; the flasher is stoped

                ; Start the flasher
                ldi             FLASHLOW, LOW(FLASHSET)
                ldi             FLASHHIGH, HIGH(FLASHSET)

FLASH10:        ; flash the LED
                cbi             PORTB, LED              ; LED lamp on

                ; time the flash
                ldi             TEMP, TIME40m           ; load time value
                rcall           WATE                    ; wate for time
                ;out            TCNT0, TEMP
                ;ldi            TEMP, MCUCRSET          ; set for idel
                ;out            MCUCR, TEMP
                ;sleep

                : stop the flash
                sbj             PORTB, LED              ; LED lamp off

                ; count the flashes
                inc             FLASHLOW                ; Adjust Count
                brne            FLASHEND
                inc             FLASHLOW                ; Can not be zero
                inc             FLASHHIGH               ; Adjust high byte
                brne            FLASHEND
                clr             FLASHLOW                ; Flash time is over stop flash
                inc             FLASHHIGH               ; Set stoped

FLASHEND:       ret

ADCRUN:         ; rutine for ADC
                ldi             TEMP, ADMUXSET
                add             TEMP, ZH
                out             ADMUX, TEMP             ; Set adc chanel
                sbi             ADCSR, ADSC             ; Start the ADC Conversion
                ;ldi            TEMP, MCUCRADC          ; set for ADC
                :out            MCUCR, TEMP
                ;sleep                                  ; wate for adc end
ADCRUN01:       sbis            ADCSR, ADIF             ; Test for end of conversion
                rjmp            ADCRUN01                ; Loop till end
                in              TEMP, ADCL              ; Get the resulats
                st              Z, TEMP
                inc             ZL
                in              TEMP, ADCH              ; Get the resulats
                st              Z, TEMP
```

FIG. 7F

```
                ret

LOADTEST:       clr     LOADOK          ; make load not OK
                ; work load test
                tst     TICB            ; test for time to run
                brne    LOADTESTEND     ; must be zero th run
                ldi     TICB, TICLOAD   ; reset the timer

                sbi     DDRB, LOAD      ; start Load by seting output

                ; time the load
                ldi     TEMP, TIME20m   ; load timer to start
                rcall   WATE

                ;out    TCNT0, TEMP
                ;ldi    TEMP, MCUCRSET  ; set for idel
                ;out    MCUCR, TEMP
                ;sleep  ;  wate for time

                ; read adc ch for SVFC
                ldi     ZH,SVFC         ; set chanel
                ldi     ZL, VFCLAN      ; data store pointer
                rcall   ADCRUN

                cbi     DDRB, LOAD      ; stop Load by try stating

                ; find load dif
                mov     VFCDIFLOW, VFCBALOW
                mov     VFCDIFHIGH, VFCBAHIGH
                sub     VFCDIFLOW, VFCLALOW
                sbc     VFCDIFHIGH, VFCLAGHIGH

                ; test dif
                cpi     VFCDIFLOW, low(loaddelta)
                ldi     TEMP, high(loaddelta)
                cpc     VFCDIFHIGH, TEMP
                brsh    LOADTESTEND

LOAD10:         doc     LOADOK          ; set load OK $FF

LOADTESTEND:    ret


;  rutine to use timer 0 for wating, Temp  time

WATE:           ;
                out     TCNT0, TEMP
                ldi     TEMP, MCUCRSET  ; set for idel
                out     MCUCR, TEMP
                sleep   ;  wate for time
                ret

Trace:          ; A lamp blinb rutine for testing
                sbic    PINb, led
                rjmp    Tracel
                sbi     PORTb, led
                cbi     PORTb, onnot
                rjmp    Traceend
Tracel:         cbi     PORTb, led
                sbi     PORTb, onnot
Traceend:       ret

EXIT
```

FIG. 7g

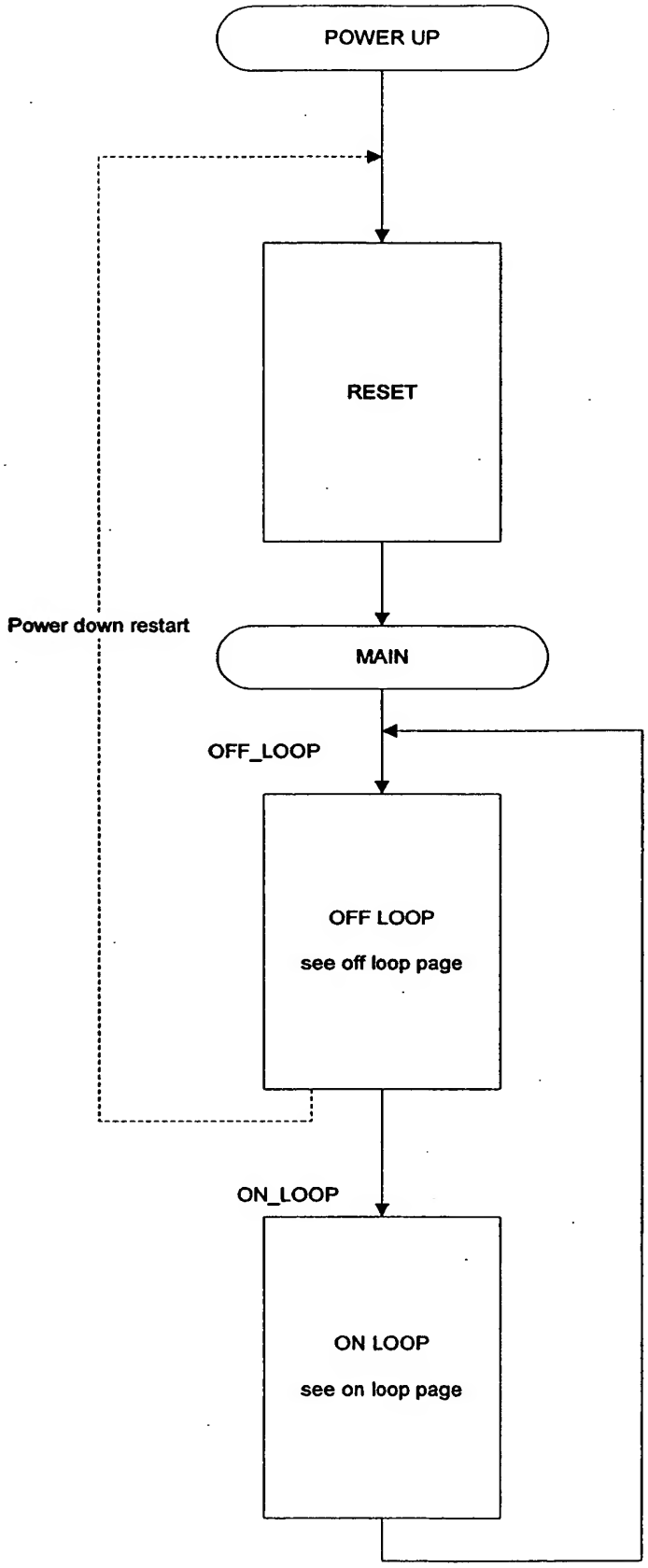

POWER UP
RESET
Power down restart
MAIN
OFF_LOOP
OFF LOOP
see off loop page
ON_LOOP
ON LOOP
see on loop page

FIG. 8a

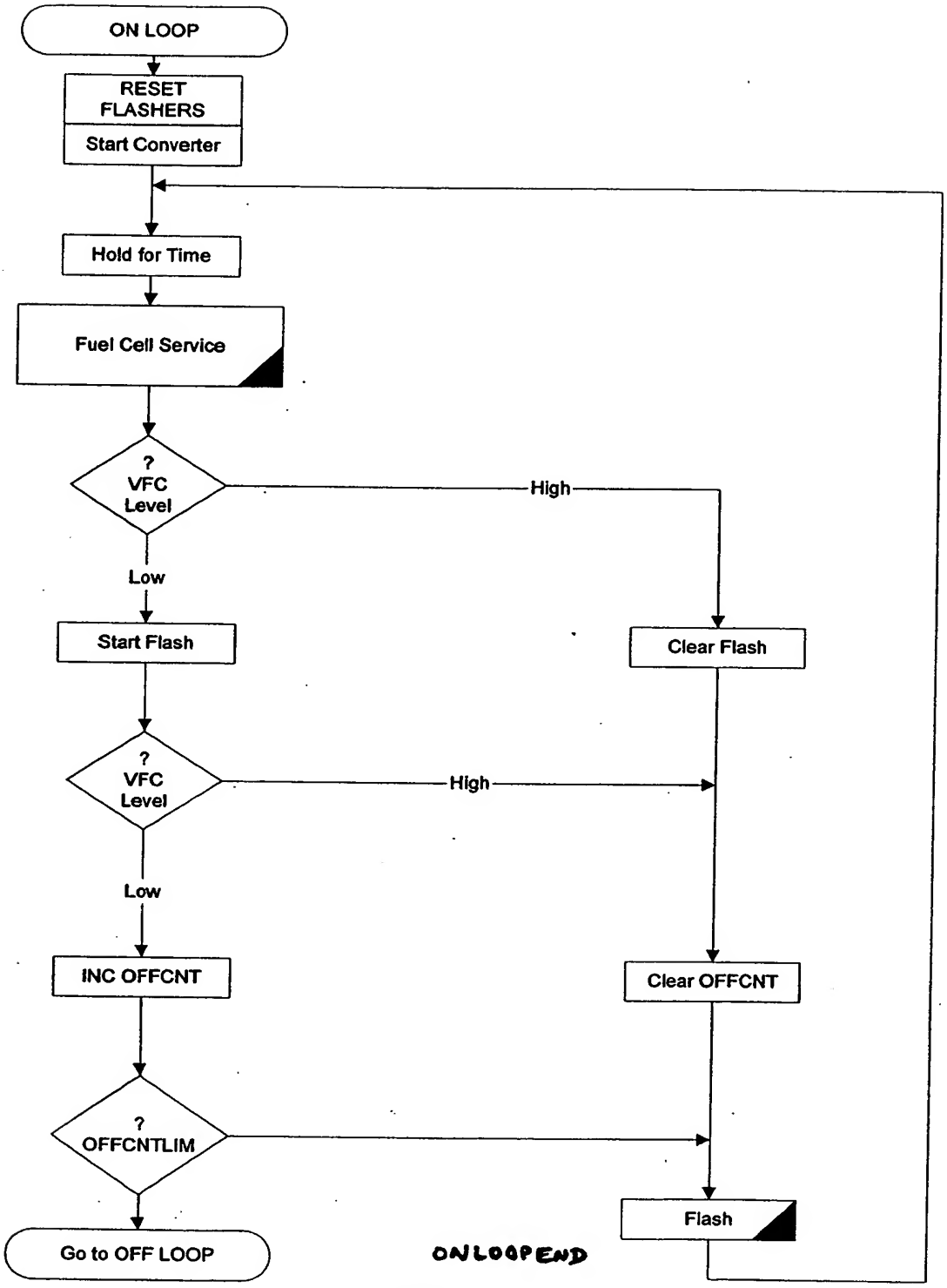

ON LOOP
RESET FLASHERS
Start Converter
Hold for Time
Fuel Cell Service
? VFC Level
High
Low
Start Flash
Clear Flash
? VFC Level
High
Low
INC OFFCNT
Clear OFFCNT
? OFFCNTLIM
Flash
Go to OFF LOOP
ONLOOPEND

FIG. 86

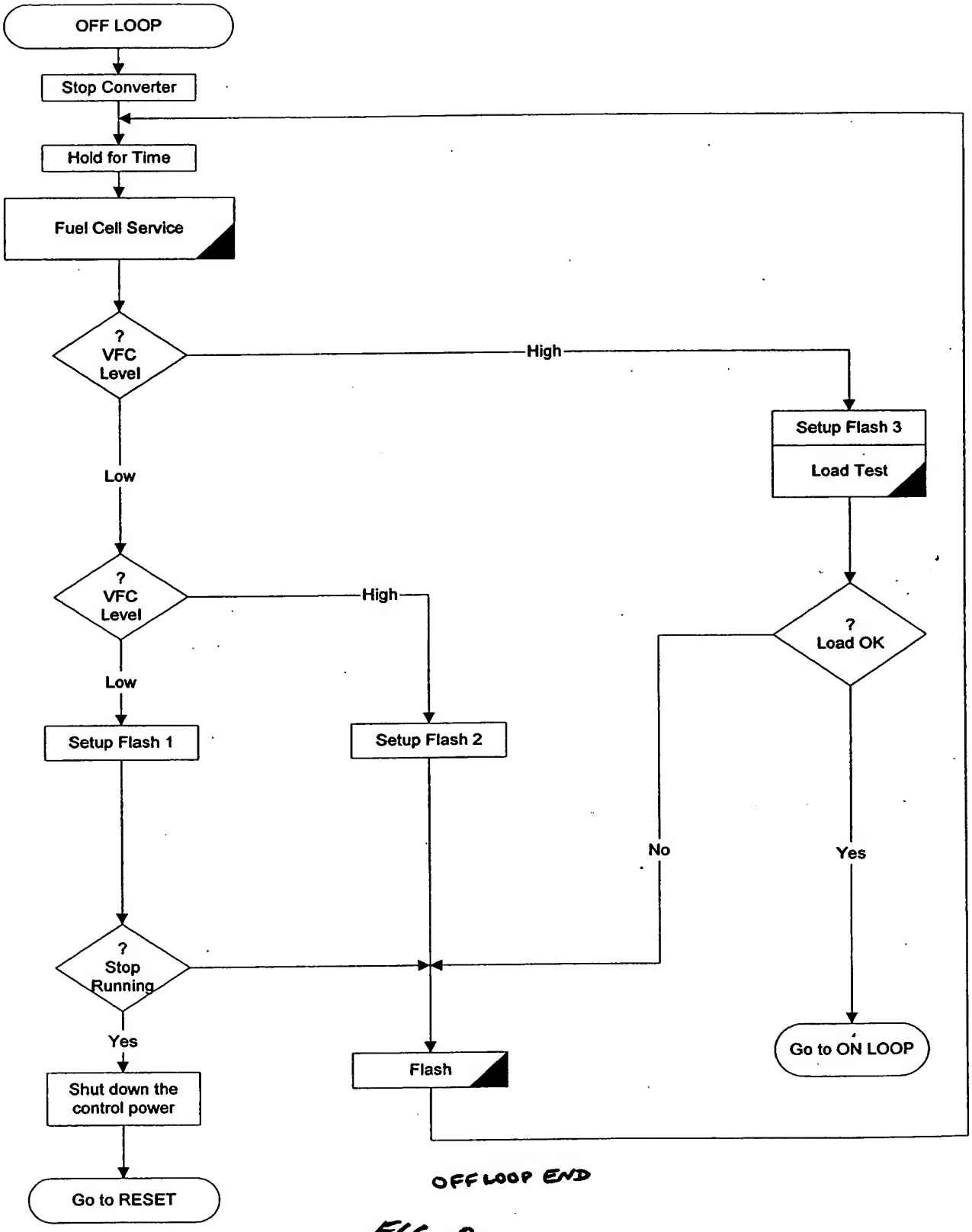
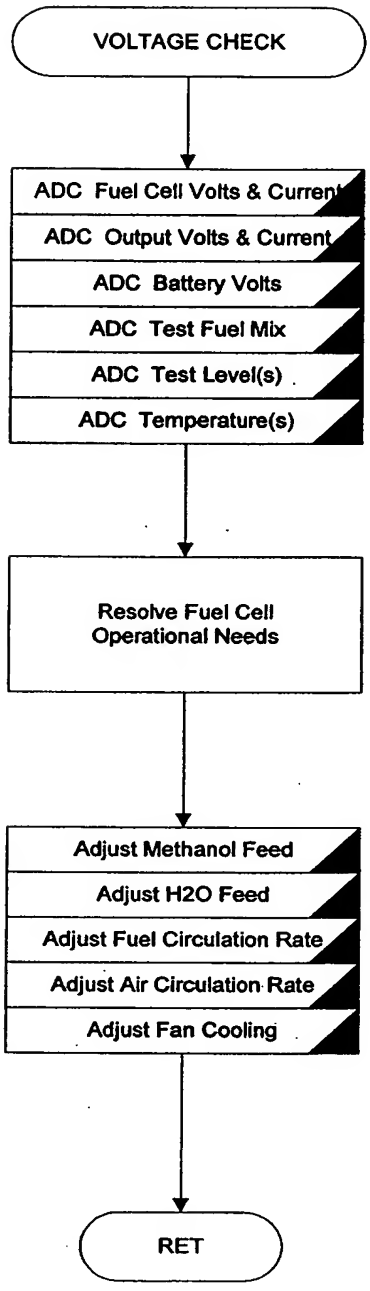

OFF LOOP
Stop Converter
Hold for Time
Fuel Cell Service
? VFC Level
High
Low
Setup Flash 3
Load Test
? VFC Level
High
Low
? Load OK
Setup Flash 1
Setup Flash 2
No
Yes
? Stop Running
Yes
Flash
Go to ON LOOP
Shut down the control power
Go to RESET
OFF LOOP END

FIG. 8c



Fuel Cell Service

FIG. 8d

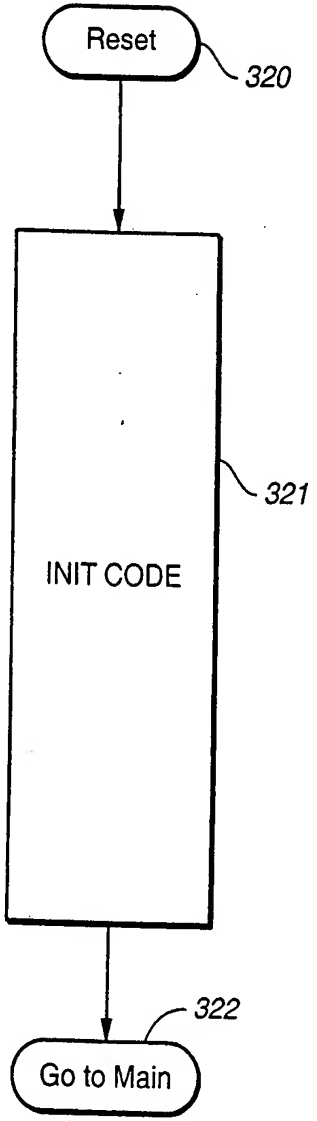


FIG. 9

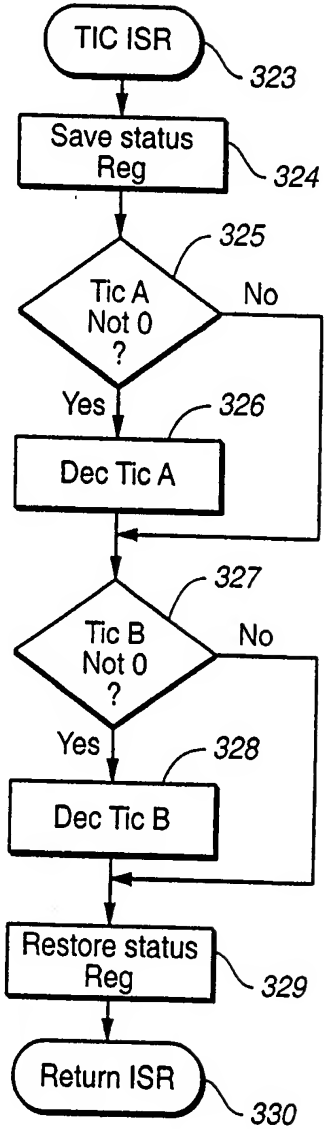


FIG. 10

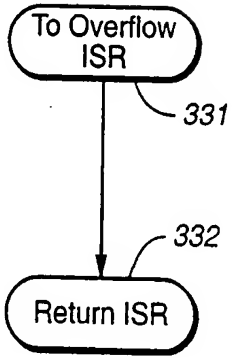


FIG. 11

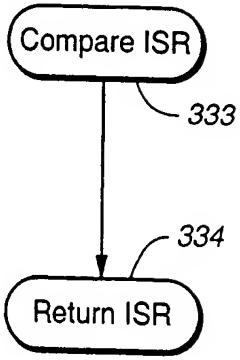


FIG. 12

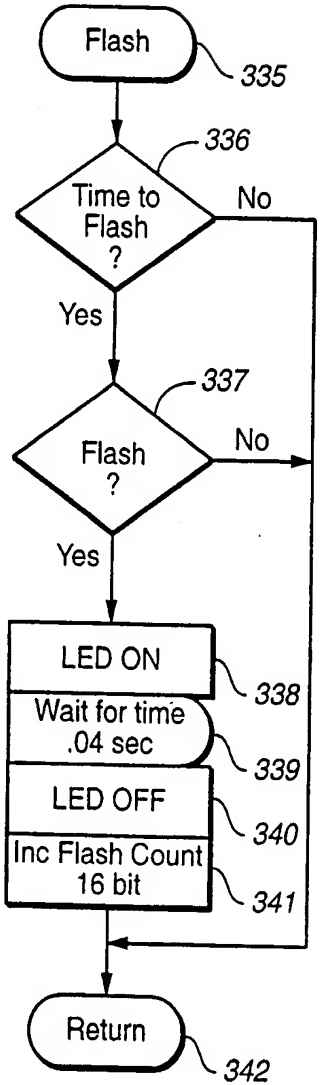


FIG. 13

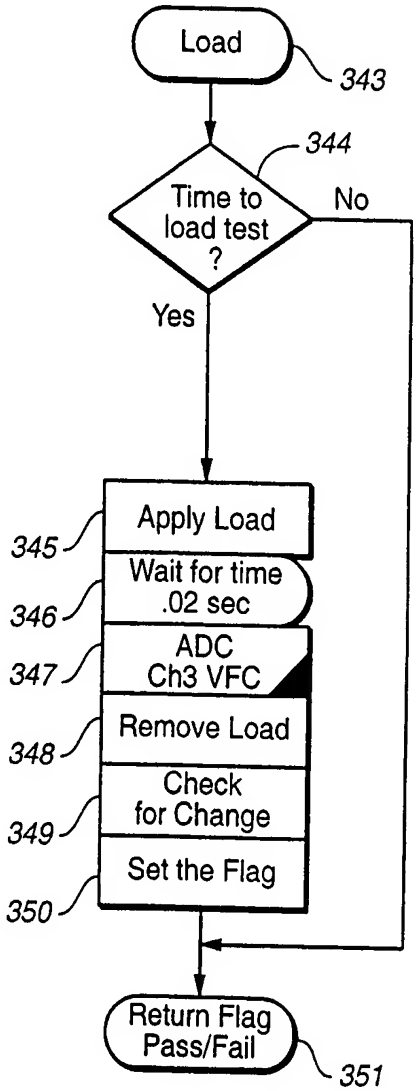


FIG. 14

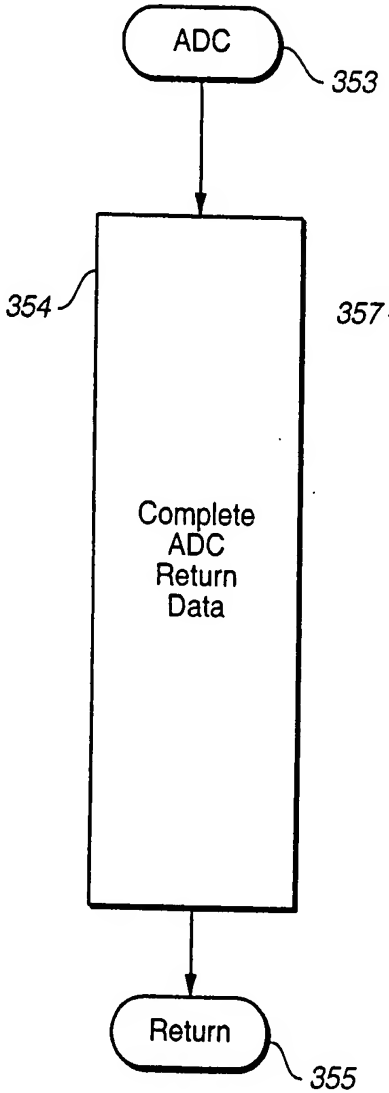


FIG. 15

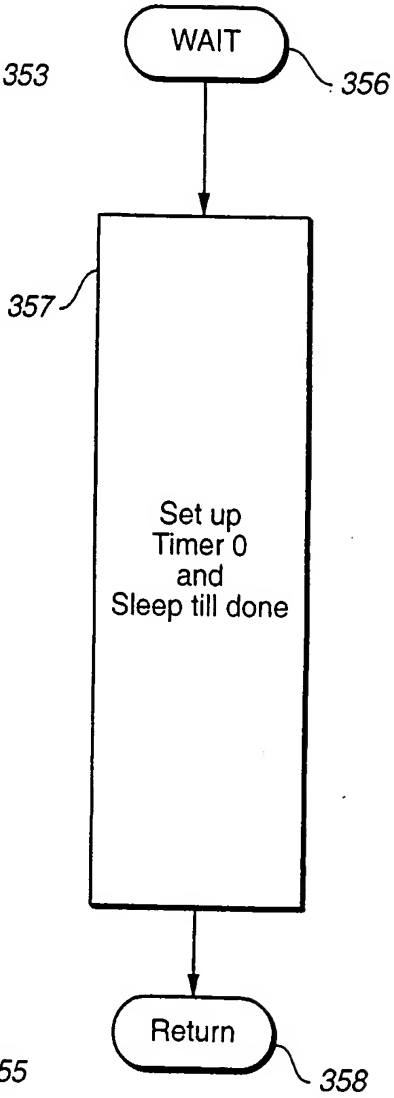


FIG. 16

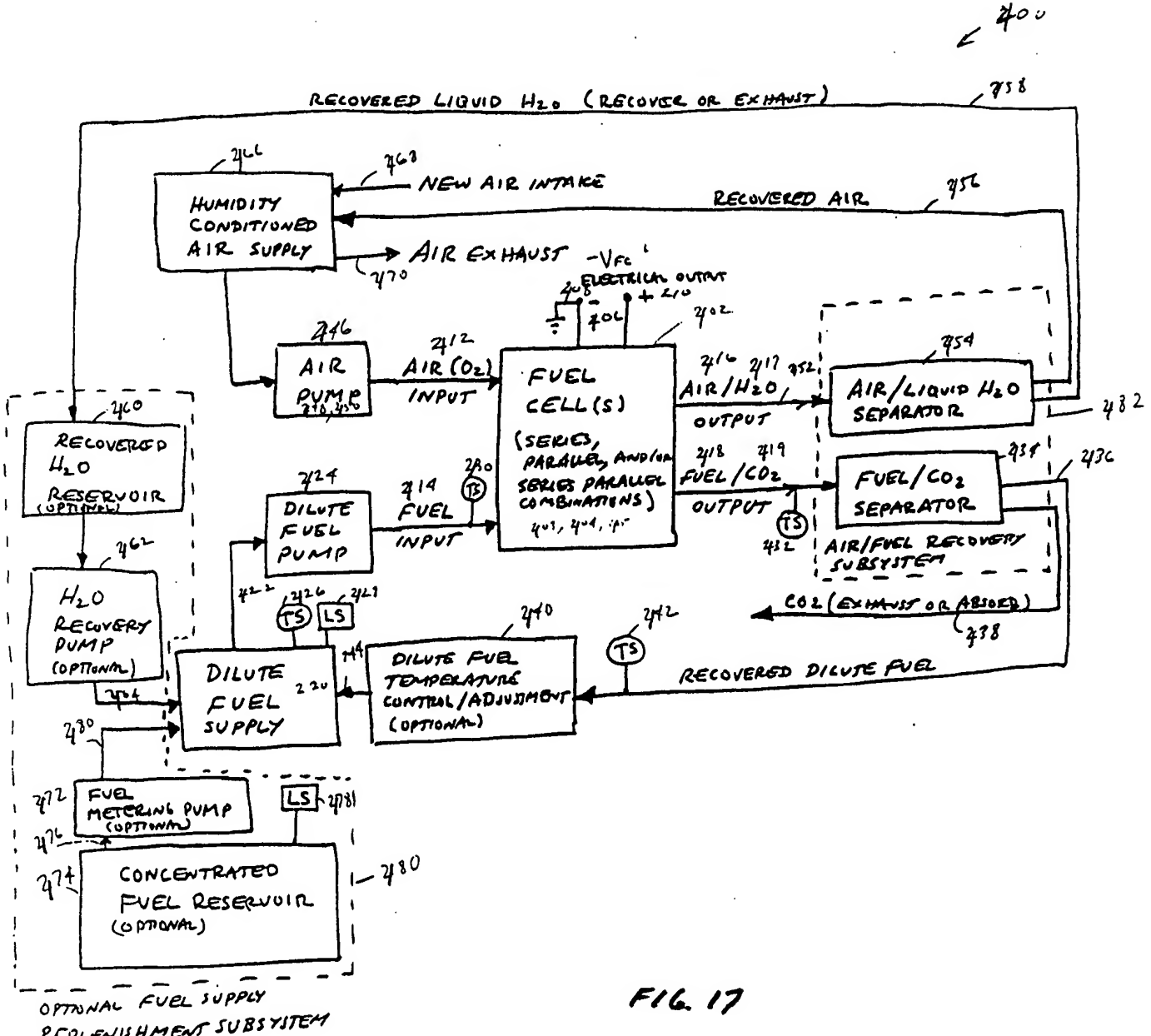

400
RECOVERED LIQUID H_2O (RECOVER OR EXHAUST)
458
HUMIDITY CONDITIONED AIR SUPPLY
466
NEW AIR INTAKE
468
RECOVERED AIR
456
AIR EXHAUST
470
$-V_{FC}$
ELECTRICAL OUTPUT
408
406
410
402
AIR PUMP
446
AIR (O_2) INPUT
412
FUEL CELL(S)
(SERIES, PARALLEL, AND/OR SERIES PARALLEL COMBINATIONS)
401, 404, 407
AIR/H_2O OUTPUT
416
417
452
AIR/LIQUID H_2O SEPARATOR
454
482
RECOVERED H_2O RESERVOIR (OPTIONAL)
460
H_2O RECOVERY PUMP (OPTIONAL)
462
DILUTE FUEL PUMP
424
FUEL INPUT
414
TS
420
FUEL/CO_2 OUTPUT
418
419
FUEL/CO_2 SEPARATOR
434
436
AIR/FUEL RECOVERY SUBSYSTEM
432
CO_2 (EXHAUST OR ABSORB)
438
422
TS
426
LS
428
DILUTE FUEL SUPPLY
220
DILUTE FUEL TEMPERATURE CONTROL/ADJUSTMENT (OPTIONAL)
440
TS
442
RECOVERED DILUTE FUEL
444
404
430
FUEL METERING PUMP (OPTIONAL)
472
LS
481
476
CONCENTRATED FUEL RESERVOIR (OPTIONAL)
474
480
OPTIONAL FUEL SUPPLY REPLENISHMENT SUBSYSTEM

FIG. 17

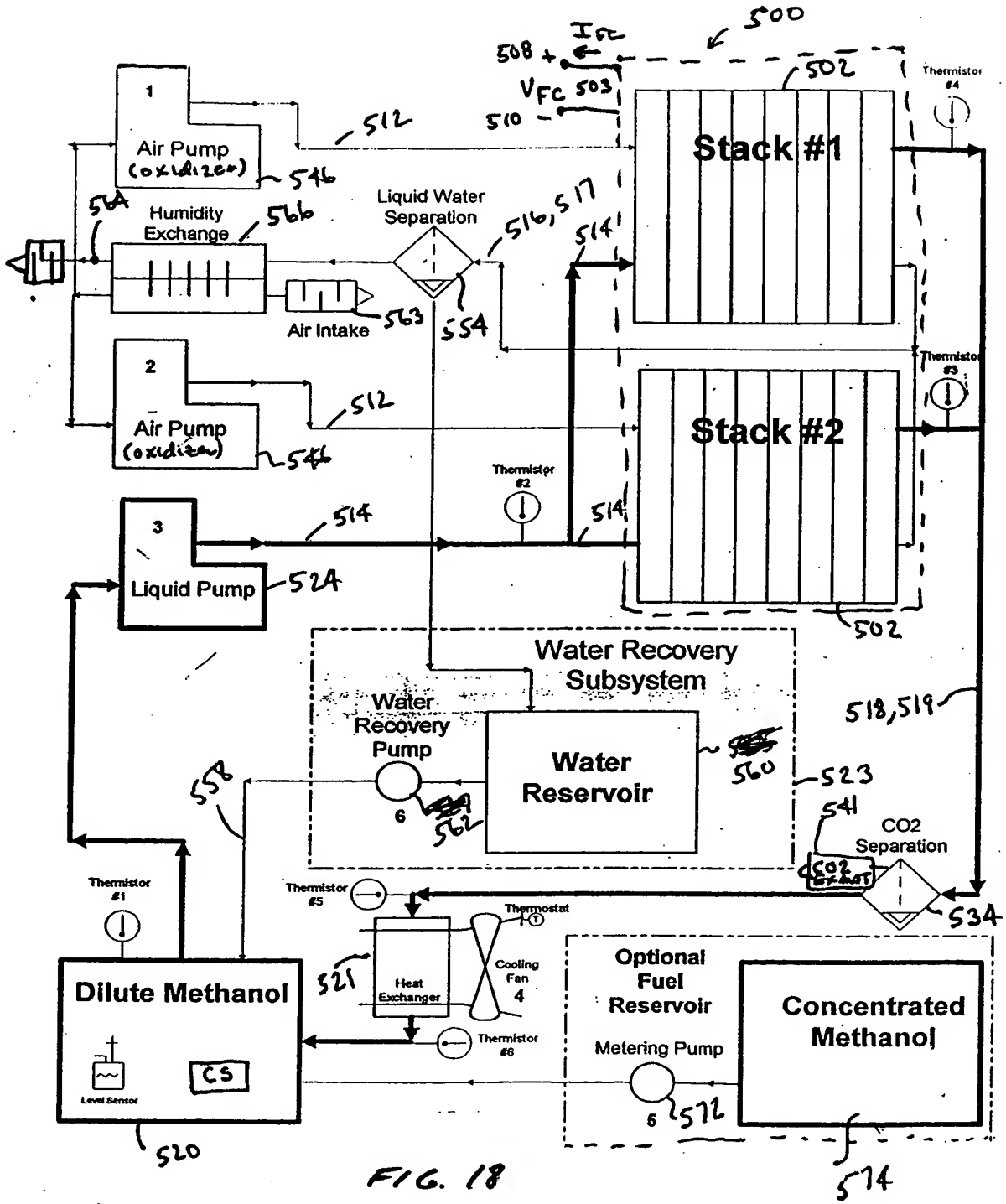

500
I_{FC}
508 +
V_{FC} 503
510
502
Thermistor #4
Stack #1
Stack #2
Thermistor #3
Thermistor #2
1
Air Pump (oxidizer)
546
512
2
Air Pump (oxidizer)
546
512
Humidity Exchange
566
564
Liquid Water Separation
516, 517
554
Air Intake
563
514
514
3
Liquid Pump
524
502
Water Recovery Subsystem
Water Recovery Pump
6
562
Water Reservoir
560
523
518, 519
558
541
CO2 Separation
CO2 Exhaust
534
Thermistor #1
Thermistor #5
Thermostat
Dilute Methanol
Level Sensor
CS
520
521
Heat Exchanger
Cooling Fan
4
Thermistor #6
Optional Fuel Reservoir
Metering Pump
6
572
Concentrated Methanol
574

FIG. 18

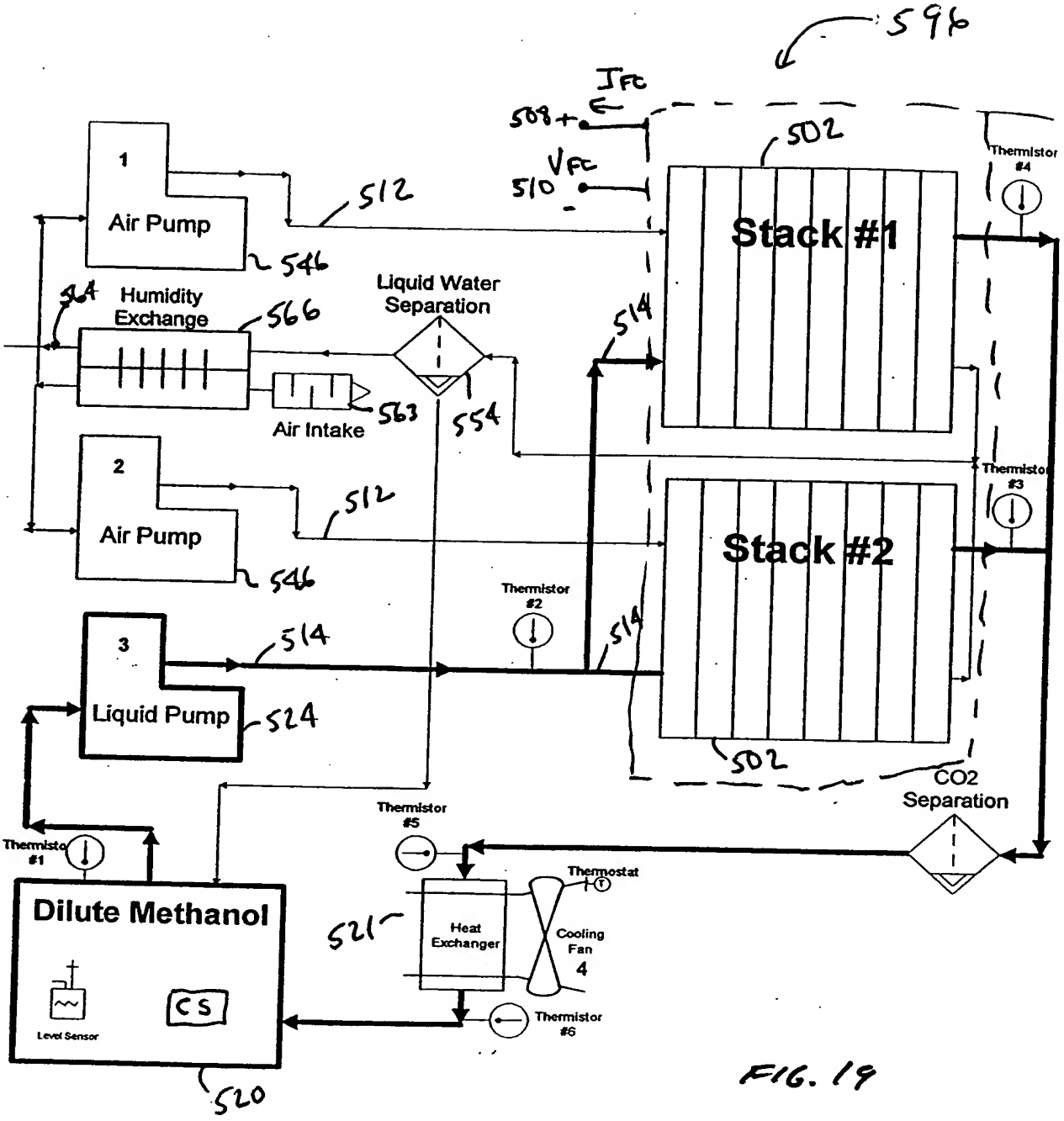

596
IFC
508
VFC
510
502
Thermistor #4
Stack #1
512
1
Air Pump
546
Humidity Exchange
566
Liquid Water Separation
514
564
Air Intake
563
554
Thermistor #3
2
Air Pump
512
546
Stack #2
Thermistor #2
514
514
3
Liquid Pump
524
502
CO2 Separation
Thermistor #5
Thermistor #1
Thermostat
Dilute Methanol
521
Heat Exchanger
Cooling Fan 4
Level Sensor
CS
Thermistor #6
520

FIG. 19

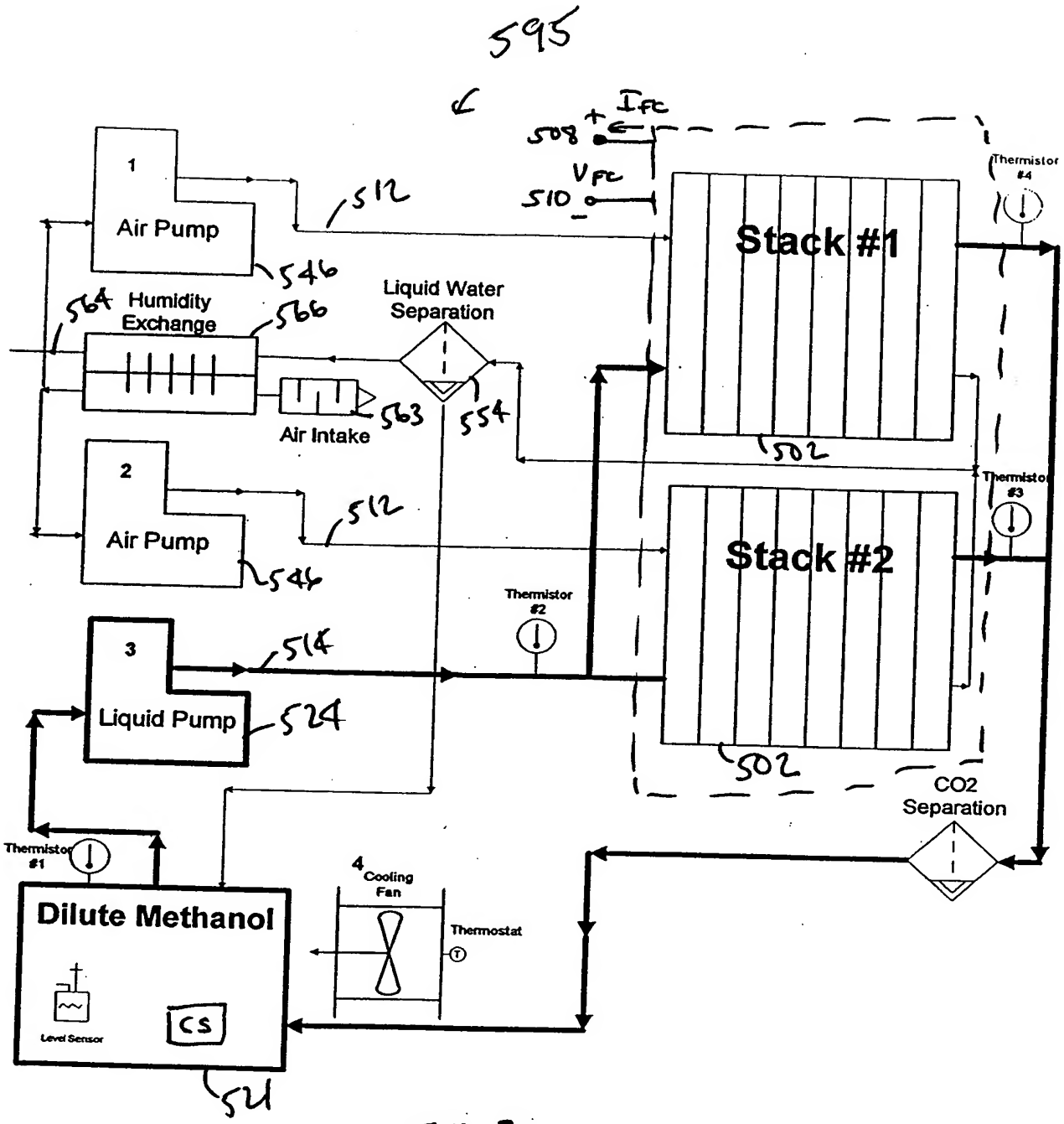

595
I_{FC}
508
V_{FC}
510
1
Air Pump
512
546
564
Humidity Exchange
566
Liquid Water Separation
563
Air Intake
554
Stack #1
502
Thermistor #4
2
Air Pump
512
546
Thermistor #3
Stack #2
Thermistor #2
3
514
Liquid Pump
524
502
CO2 Separation
Thermistor #1
4
Cooling Fan
Thermostat
Dilute Methanol
Level Sensor
CS
54

FIG. 20

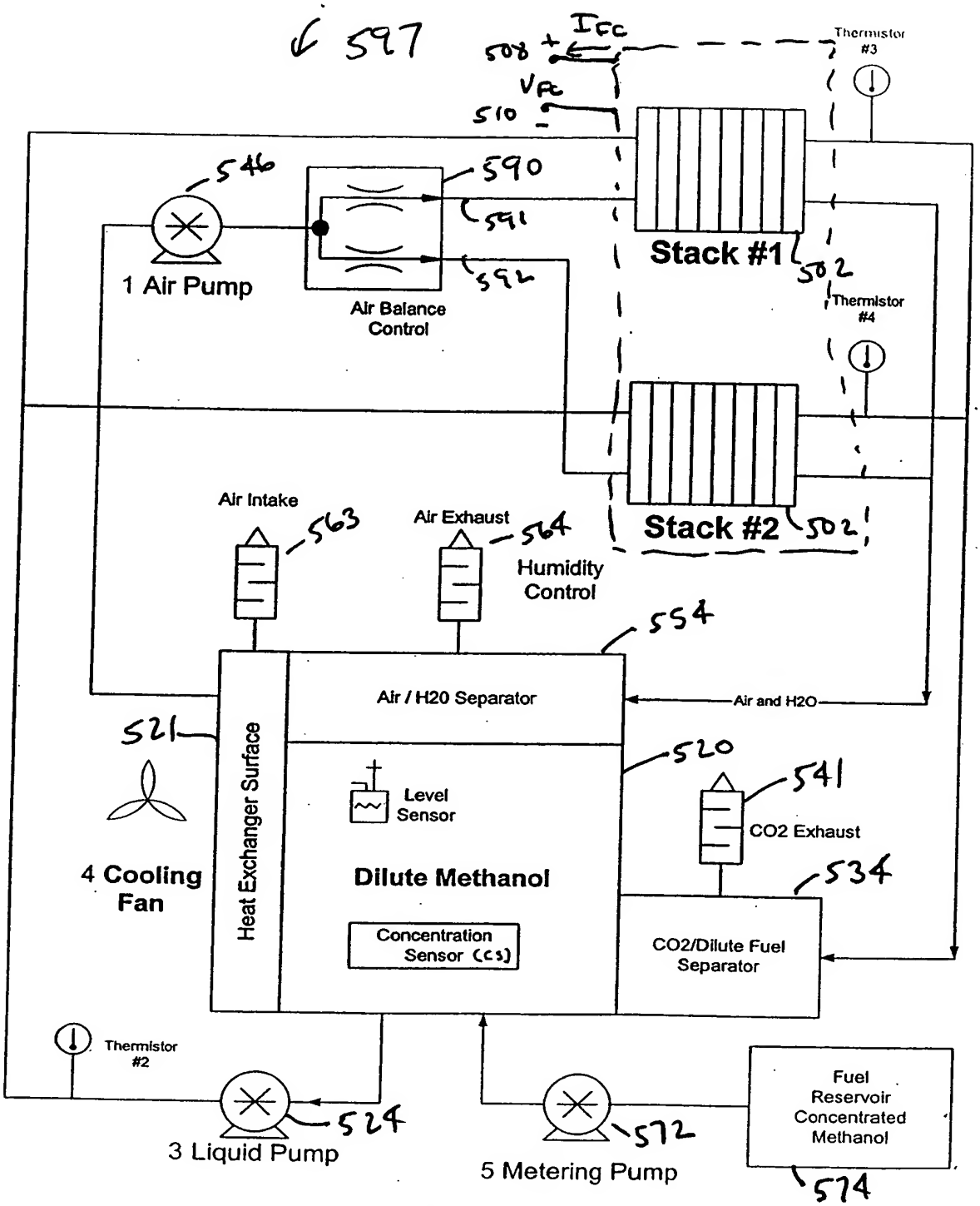

597
Icc
508
+
VFC
510
-
Thermistor #3
546
590
591
592
1 Air Pump
Air Balance Control
Stack #1
502
Thermistor #4
Stack #2
502
Air Intake
563
Air Exhaust
564
Humidity Control
554
Air / H20 Separator
Air and H2O
521
520
541
Level Sensor
CO2 Exhaust
4 Cooling Fan
Heat Exchanger Surface
Dilute Methanol
534
Concentration Sensor (CS)
CO2/Dilute Fuel Separator
Thermistor #2
524
572
Fuel Reservoir Concentrated Methanol
574
3 Liquid Pump
5 Metering Pump
Laptop Simple System

FIG. 21

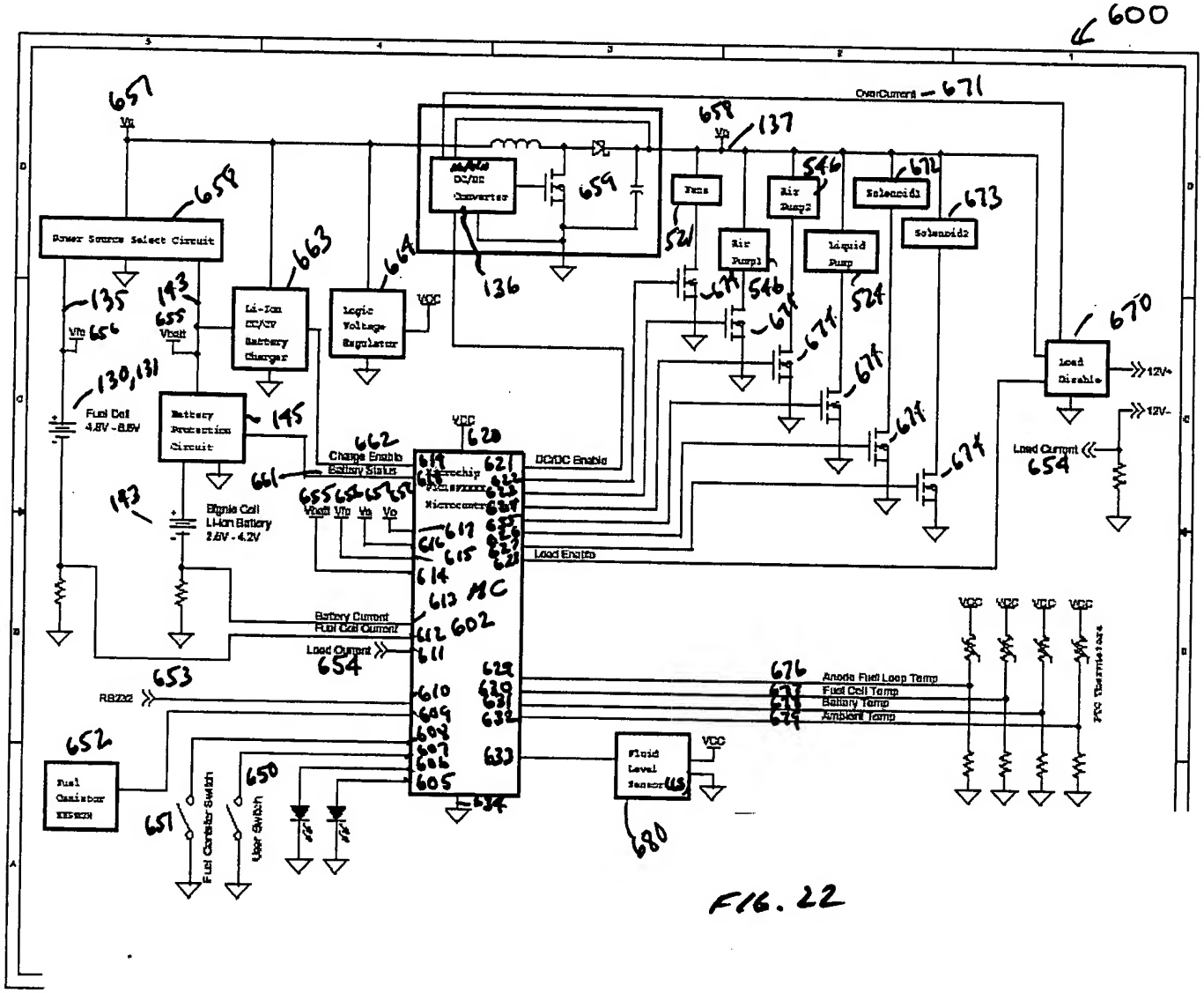

600
OverCurrent
671
Power Source Select Circuit
659
DC/DC Converter
Fans
524
Air Pump2
546
Solenoid1
672
Solenoid2
673
Air Pump1
Liquid Pump
Li-Ion CC/CV Battery Charger
663
Logic Voltage Regulator
667
VCC
136
137
Load Disable
670
12V+
12V-
Load Current
654
Fuel Cell
4.8V - 8.6V
130,131
Battery Protection Circuit
195
193
Bipolar Cell
Li-Ion Battery
2.6V - 4.2V
Charge Enable
Battery Status
662
661
DC/DC Enable
Load Enable
620
MC
602
Battery Current
Fuel Cell Current
Load Current
654
653
RS232
652
Fuel Canister
Fuel Canister Switch
User Switch
650
651
Fluid Level Sensor
680
Anode Fluid Loop Temp
Fuel Cell Temp
Battery Temp
Ambient Temp
676
PTC Thermistor

FIG. 22

Macroscopic Control Diagram

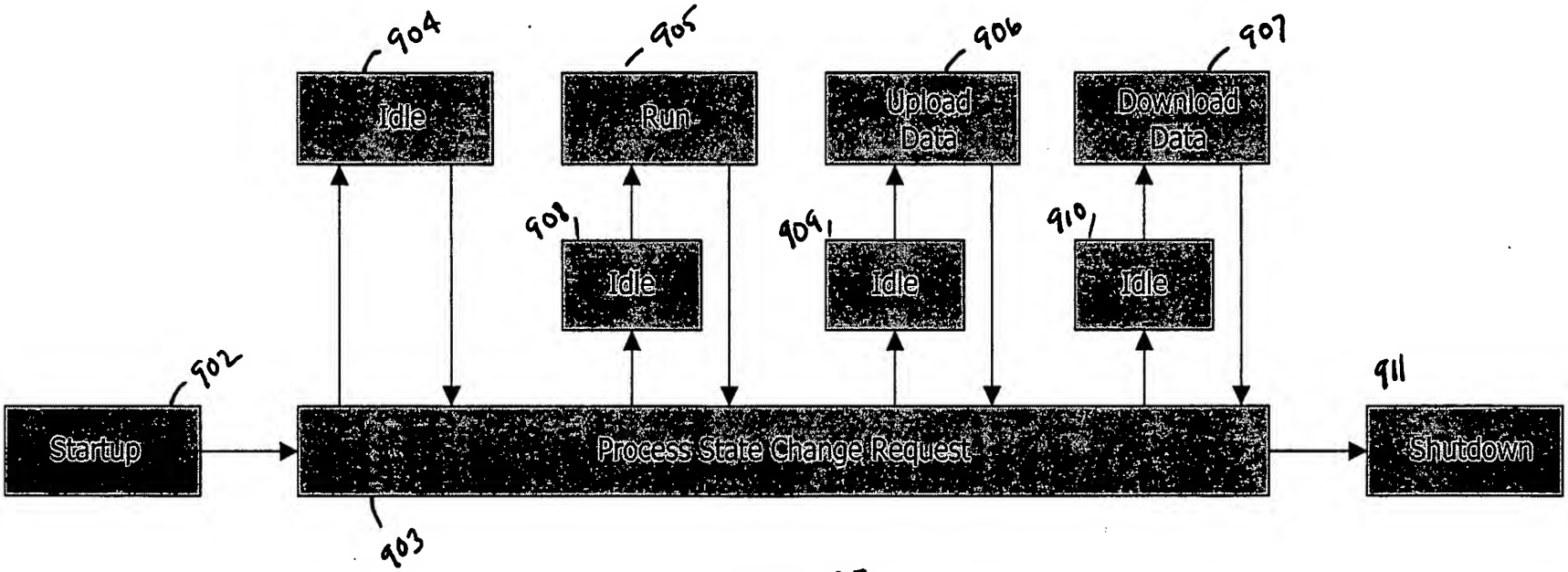


FIG. 23

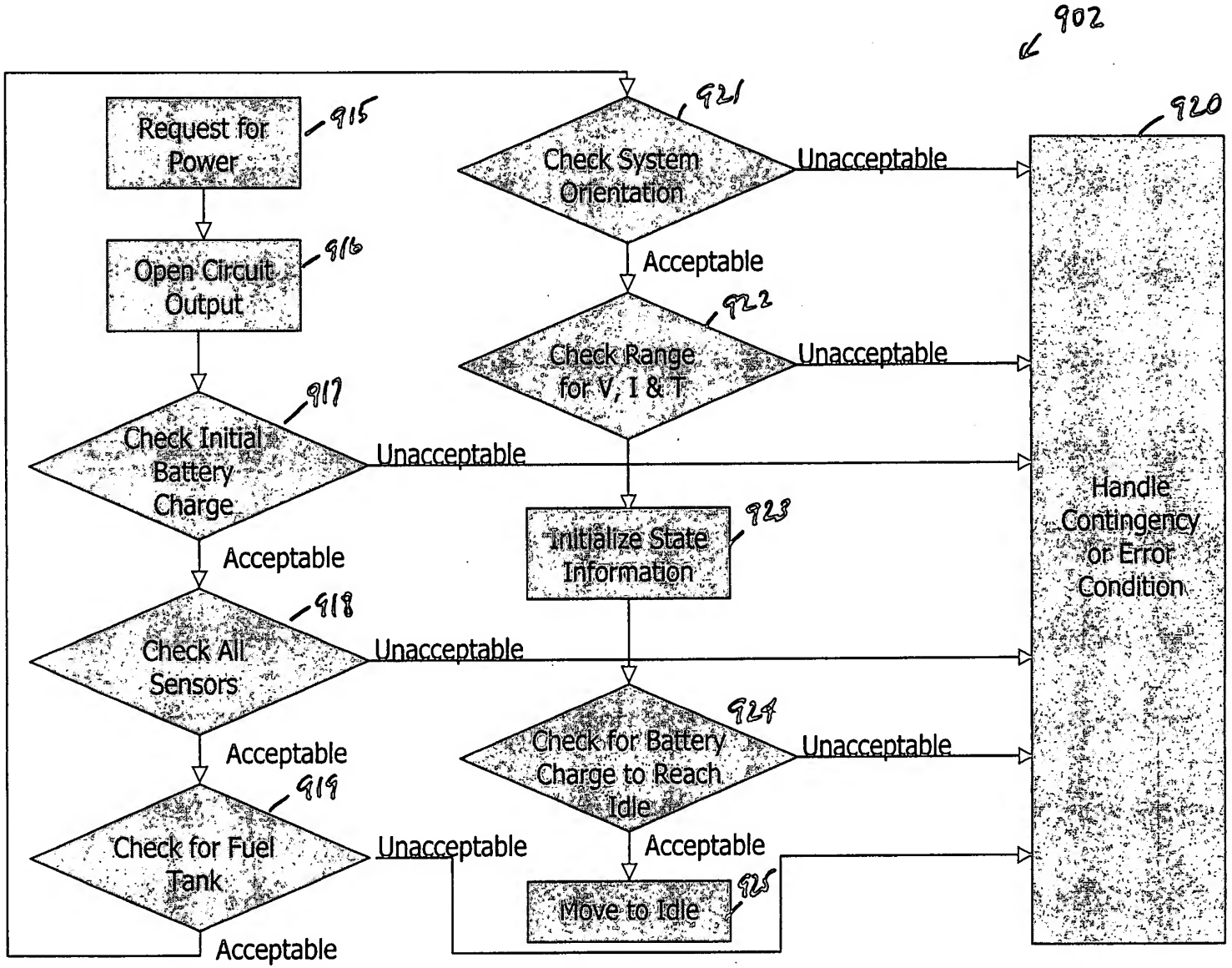

902
Request for Power
915
Open Circuit Output
916
Check Initial Battery Charge
917
Check All Sensors
918
Check for Fuel Tank
919
Check System Orientation
921
Check Range for V, I & T
922
Initialize State Information
923
Check for Battery Charge to Reach Idle
924
Move to Idle
925
Handle Contingency or Error Condition
920
Unacceptable
Acceptable

FIG. 24

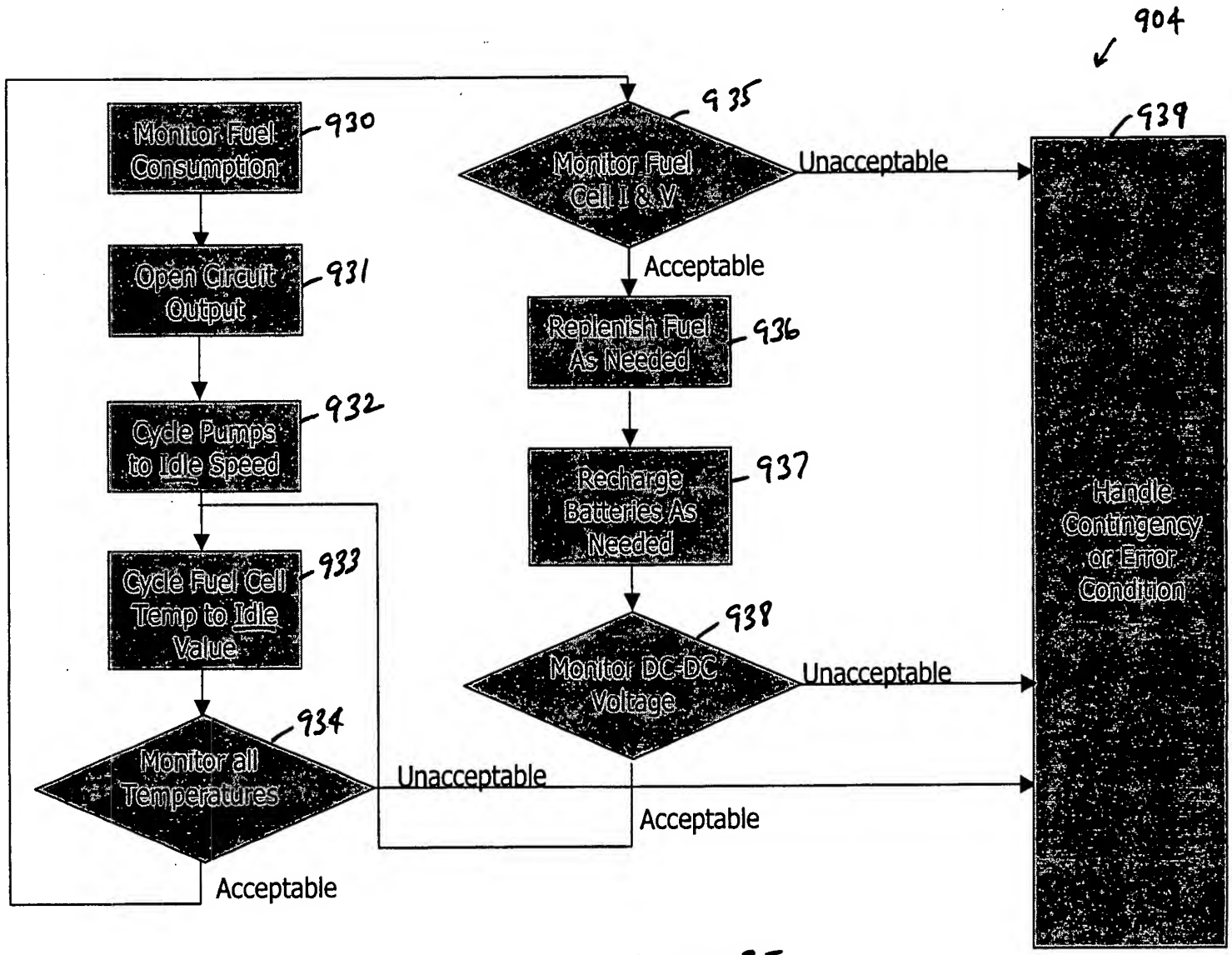

904
Monitor Fuel Consumption
930
Open Circuit Output
931
Cycle Pumps to Idle Speed
932
Cycle Fuel Cell Temp to Idle Value
933
Monitor all Temperatures
934
Acceptable
Unacceptable
Acceptable
Monitor Fuel Cell I & V
935
Unacceptable
Acceptable
Replenish Fuel As Needed
936
Recharge Batteries As Needed
937
Monitor DC-DC Voltage
938
Unacceptable
Acceptable
939
Handle Contingency or Error Condition

FIG. 25

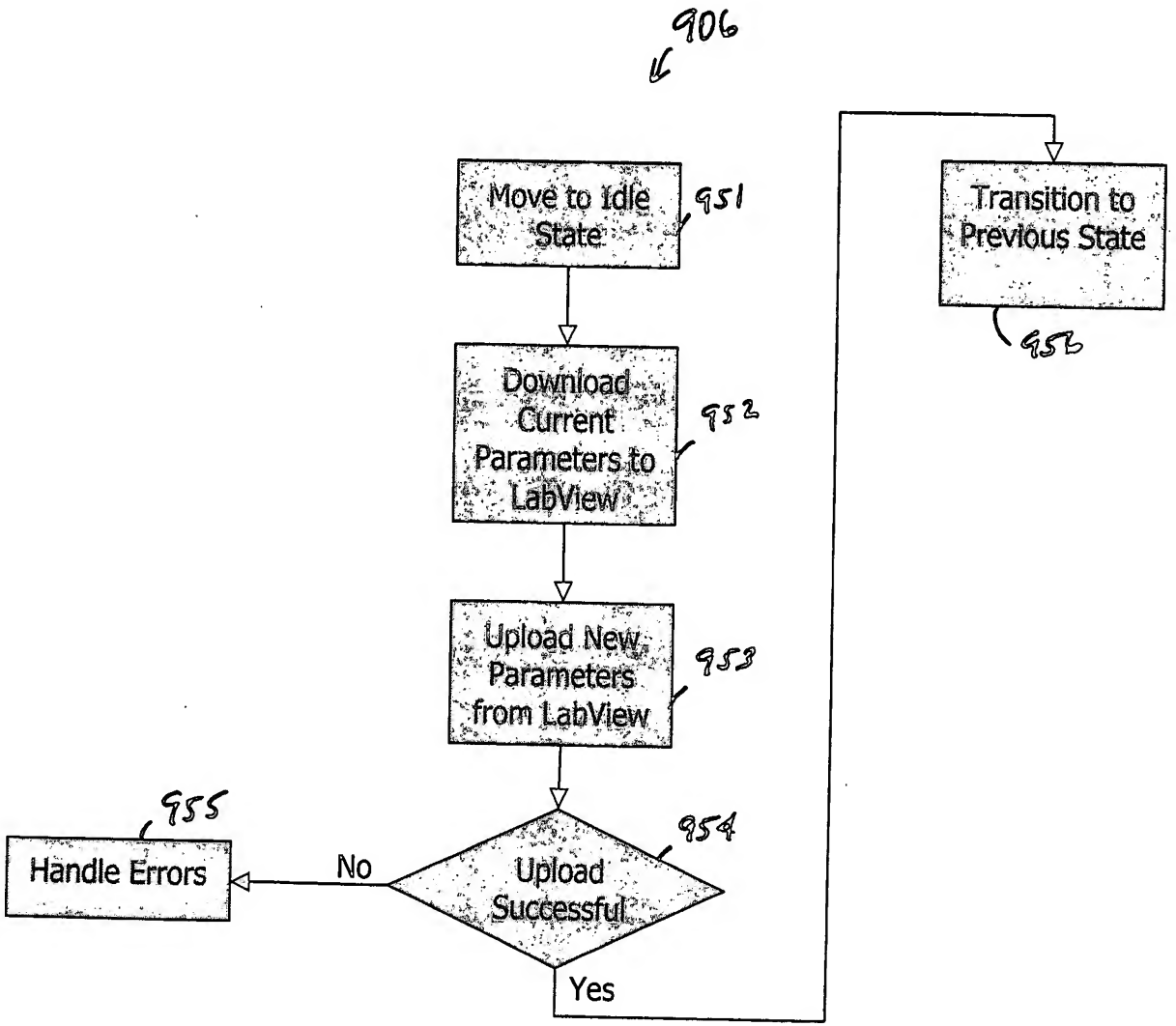

906
Move to Idle State
951
Download Current Parameters to LabView
952
Upload New Parameters from LabView
953
Upload Successful
954
No
Handle Errors
955
Yes
Transition to Previous State
956

FIG. 26

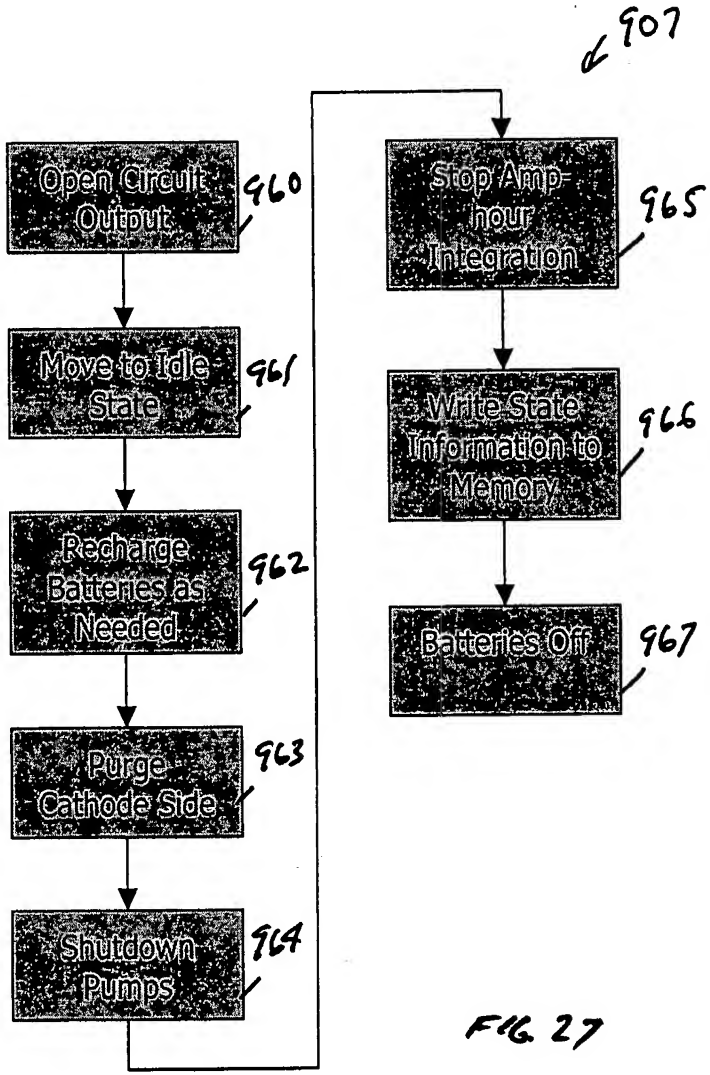

907
Open Circuit Output
960
Move to Idle State
961
Recharge Batteries as Needed
962
Purge Cathode Side
963
Shutdown Pumps
964
Stop Amp-hour Integration
965
Write State Information to Memory
966
Batteries Off
967

FIG 27

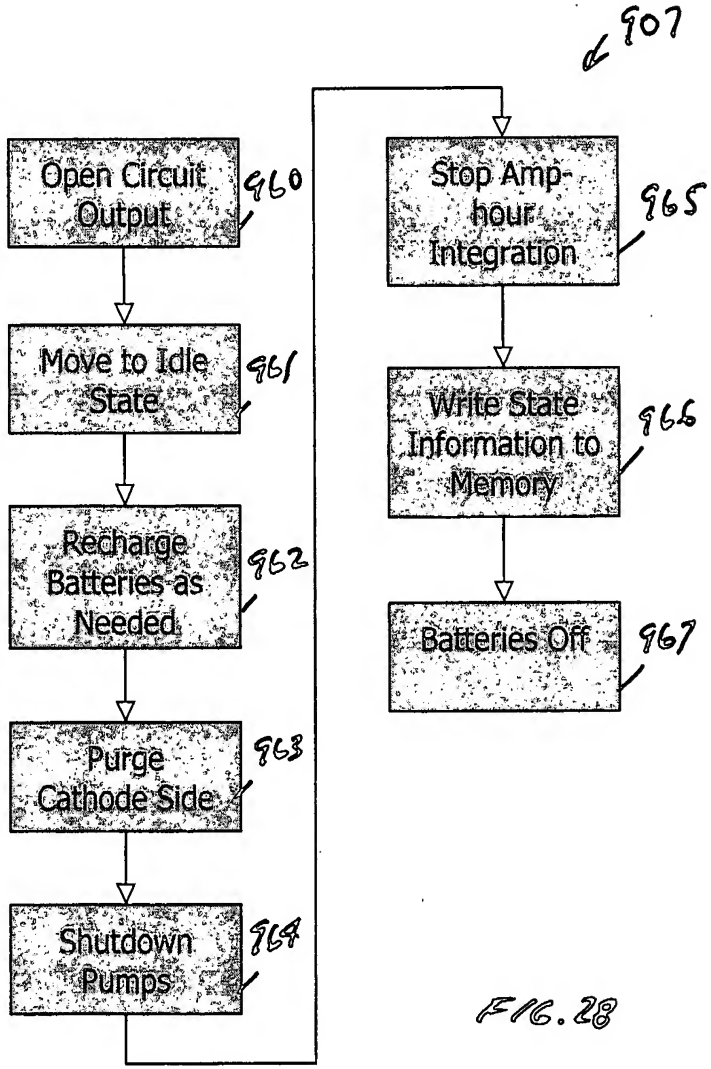

907
Open Circuit Output
960
Move to Idle State
961
Recharge Batteries as Needed
962
Purge Cathode Side
963
Shutdown Pumps
964
Stop Amp-hour Integration
965
Write State Information to Memory
966
Batteries Off
967

FIG. 28

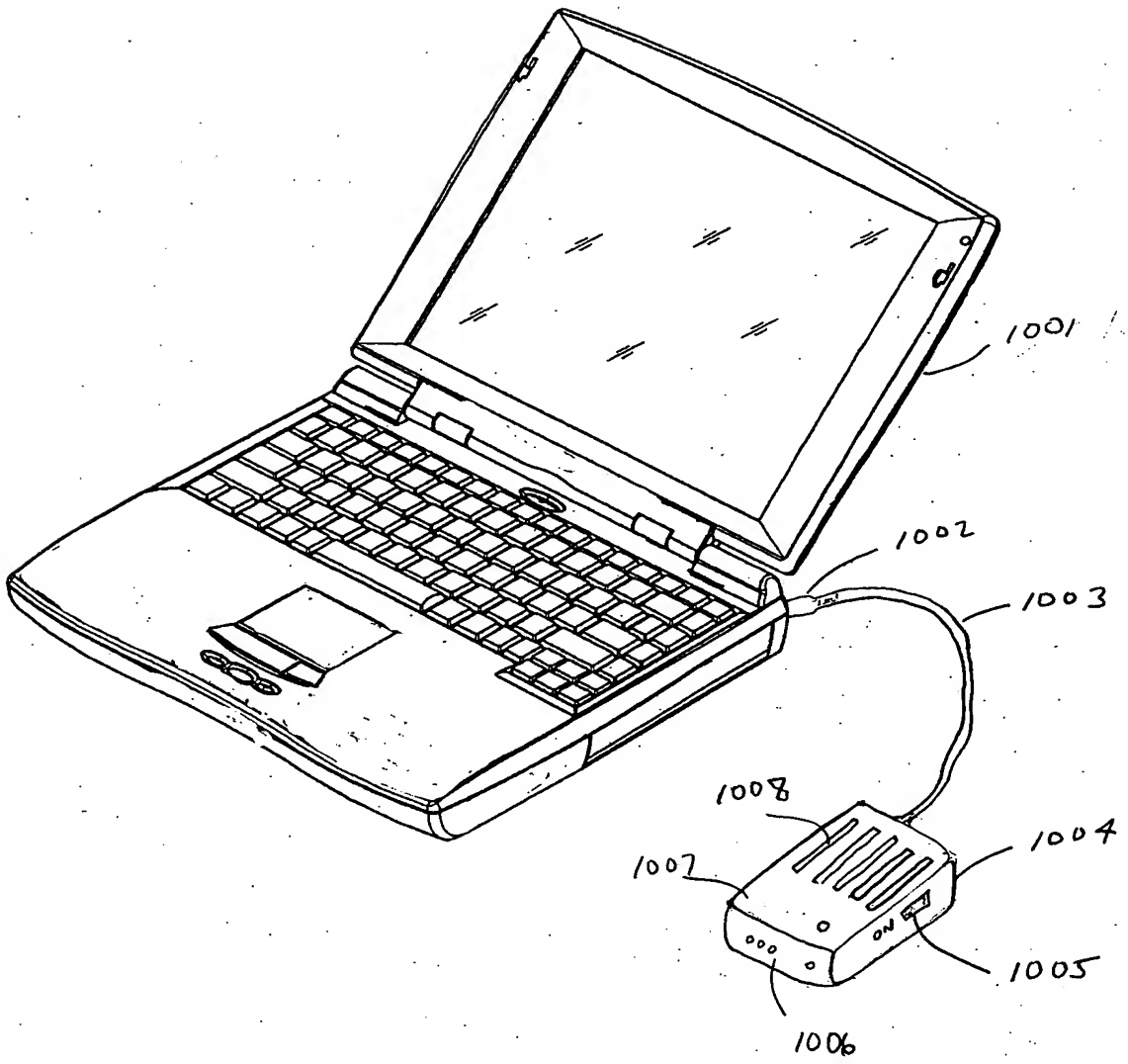


FIG. 29